

HUGHES

**Space and Communications Group
GOVERNMENT ELECTRONICS SYSTEMS DIVISION**

HS256C-1045-0061

FINAL REPORT

FOR THE HIGH RESOLUTION MICROWAVE SPECTROMETER SOUNDER (HIMSS) INSTRUMENT PROGRAM

AN INSTRUMENT FOR NASA'S EARTH OBSERVING SYSTEM

VOLUME 1, BOOK 2

OCTOBER 1990

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HIGH RESOLUTION MICROWAVE SPECTROMETER SOUNDER (HIMSS)

FINAL REPORT

VOLUME 1, BOOK 2

PRELIMINARY PROGRAM PLANS

CEI SPECIFICATION

INSTRUMENT INTERFACE DESCRIPTION DOCUMENT

CONTRACT NO. NAS8-38175

SUBMITTED TO:

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GEORGE C. MARSHALL SPACE FLIGHT CENTER**

BY:

HUGHES

**SPACE AND COMMUNICATIONS GROUP
GOVERNMENT ELECTRONICS SYSTEMS DIVISION**

FOREWORD

This High Resolution Spectrometer Sounder Final Report has been prepared for Marshall Space Flight Center, under contract no. NAS8-38175, and it is submitted in compliance with the contract deliverables, data item 5. This report also includes the preliminary program plans, CEI specification and Instrument interface description document.

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5.0 CONTRACT END ITEM (CEI) SPECIFICATION - PRELIMINARY

6.0 INSTRUMENT INTERFACE DESCRIPTION DOCUMENT

ACRONYMS

ABM	Active balancing mechanism
AO	Announcement of opportunity
ASIC	Application specific integrated circuit
AUSSAT	Australian satellite built by Hughes
BAPTA	Bearing and power transfer assembly
BCE	BAPTA control electronics
BDU	Bus data unit
BSR	Bus select relay
CDR	Critical design review
CPT	Comprehensive performance test
dB	deciBell
DMSP	Defense Meteorological Satellite Program
Eos	Earth observing system
EMC	Electromagnetic compatibility
EMI	Electromagnetic interference
ECRA	Electrical contact ring assembly
FET	Field effect transistor
FFT	Full functional test
GE	General Electric
GHz	Giga Hertz
GIIS	General instrument interface specification
GMS	Geostationary Meteorological Satellite
GSE	Ground support equipment
HIMSS	High resolution microwave spectrometer sounder
HTR	Heater
ICWG	Interface control working group
in	Inch
K	Kelvin
Kg	Kilogram
Km	Kilometer
KRTR	Kit requisition and traceability record
lbm	pound
LFT	Limited functional test
LO	Local oscillator
LNA	Low noise amplifier
m	Meter
Mbps	Mega bits per second
MHz	Mega Hertz
MIC	Multi-layer integrated circuit
MIP	Master index pulse
MMB	Multi mission bus
MRR	Manufacturing readiness review
mS	milli-second
MSFC	Marshall Space Flight Center
MWA	Momentum wheel assembly
N	Newton
N/A	Not applicable

OMT	Ortho-mode transducer
PROM	Programmable read-only memory
PDR	Preliminary design review
PRR	Preliminary requirements review
PQR	Program quality requirements
PS	Power supply
PSP	Payload support plate
PSS	Payload support structure
PWB	Printed wiring board
RCVR,REC	Receiver
RDA	Reflector deployment actuator
RF	Radio frequency
rms	Root mean square
rpm	Revolutions per minute
QCHR	Quality control history record
S/C	Spacecraft
SCG	Space and Communications Group
SCU	Speed control unit
SIC	Standard interface connector
SOW	Statement of work
SPU	Signal processing unit
SSM/I	Special sensor microwave/imager
SST	Sea surface temperature
T	Temperature
TBD	To be determined
TBR	To be resolved/reviewed
TV	Thermal vacuum
UHF	Ultra high frequency
V	Volts
VDA	Vapor deposited aluminum
VLSI	Very large scale integration
W	Watts

4.0 PRELIMINARY PROGRAM PLANS

The complete preliminary plans are attached.

4.1 SPARES PLAN

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HS256C-1045-0054

SPARES PLAN

FOR THE
**HIGH RESOLUTION MICROWAVE
SPECTROMETER SOUNDER
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AN INSTRUMENT FOR NASA'S
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PRELIMINARY

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ATTACHEMENT 1: SPACE AND COMMUNICATIONS GROUP
MATERIEL INSTRUCTION - MATERIAL ATTRITION

1.0 INTRODUCTION

1.1 PURPOSE

The purpose of this Spares plan is to identify all the spare components, parts, assemblies, and subsystems that are required for the successful completion of the HIMSS program.

1.2 SCOPE

This document establishes a sparing philosophy that assures the reduction of turn-around time in the event a failure occurs during spacecraft integration and test, or anytime before launch.

2.0 APPLICABLE DOCUMENTS

The following list of documents forms a part of this plan to the extent specified herein.

Hughes

TBD
Materiel Instruction
8-30-15.1

Storage of Flight Spares
Materiel Attrition

NASA

TBD

3.0 SPARING PHILOSOPHY

The HIMSS program has provided for two categories of spares to support the development and production phases of the program. The first category accommodates attrition and is procured to offset anticipated losses during normal development and production programs, i.e., for failed, damaged, destroyed, scrapped, and destructively tested parts throughout the program.

The second category of spares is at the subsystem level and they are a contractual line item. These spares are complete units or components, ready to be integrated and then system tested.

3.1 ATTRITION

The quantities of material ordered to accommodate attrition is based on the Hughes Aircraft Company's experience in the production of electronic systems, and is described in the Hughes Space and Communications Group Materiel Instruction No. 8-30-15.1 (Attachment 1)

3.2 PROGRAM SPARES

The full set of spares consists of components and units manufactured and acceptance tested at the unit level. Table 1 lists these items.

TABLE 1. HIMSS PROGRAM SPARES

SUBSYSTEM	COMPONENT/UNIT TO BE SPARED
ANTENNA	REFLECTOR, CALIBRATION LOADS: COLD SKY REFLECTOR AND WARM LOADS
RECEIVER	COMPLETE SET OF INDIVIDUAL RECEIVERS
SIGNAL PROCESSING	SIGNAL PROCESSING UNIT
POWER SUPPLY	PRECONVERTER, BIAS POWER SUPPLY, FULL SET OF POST-REGULATORS
MECHANISMS AND CONTROLS	BAPTA, BAPTA CONTROL ELECTRONICS, MOMENTUM WHEEL ASSEMBLY, SPEED CONTROL UNIT, REFLECTOR DEPLOYMENT ACTUATOR, PYROTECHNICS
STRUCTURES	ANTENNA AND SENSOR STRUCTURES, PAYLOAD SUPPORT STRUCTURE

3.3 SPARES MANAGEMENT

The Parts Manager is responsible for all parts on the HIMSS program. He will also be responsible for all attrition and spare parts. He reports directly to the Performance Assurance Manager.

4.0 SPARES STORAGE

The spares will be stored in flight stores, per the Program Instruction TBD, and tracked in the same manner as all other flight parts.

ATTACHMENT 1

SPACE AND COMMUNICATIONS GROUP
MATERIEL INSTRUCTION

No 8-30-15.1

SUBJECT Material Attrition

SUPERSEDES Group Materiel Instruction 8-30-15.1, dated 06-23-89

REFERENCE Company Policy 8-1, "Materiel"
 Company Practice 8-30-14, "Inventory Management"
 Group Practice 8-30-15, "Control of Direct Charge Material"
 Company Finance Property Practice 9-5-1, "Material Control"
 Group Property Instruction 9-5-1, "Material Control"

PURPOSE To define the application of material attrition for either proposal preparation and submittal or materials acquisition in support of a prime contract.

APPLICABLE To all within SCG

FORM USED Stores Transaction (11926 SC)

DEFINITION Attrition Quantity - The amount of material that is proposed or ordered in addition to basic contract requirements to reduce reorder costs and minimize schedule delays. Attrition quantities are used to replace failed, damaged, destroyed, scrapped, and lost material.

Pure Quantity - The exact amount of material required to manufacture an item.

Actual Experienced Attrition - The attrition quantity resulting from replacement of material or cycle inventory losses.

Instruction

1. Attrition Procedure

1.1 The requesting organizations determine attrition quantities for all material required to successfully complete contracts while avoiding excessive residual materials. Attrition is determined for both proposal preparation and for the acquisition of materials.

1.1.1 Reasonableness in determining attrition quantities is paramount. In some cases, minimal or zero attrition allowance may be appropriate based upon high unit cost or unique experience; in other cases, higher quantity allowances may be required.

Revision

Date: 03/30/90

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SPACE AND COMMUNICATIONS GROUP
MATERIEL INSTRUCTION

SUBJECT Material Attrition

No.
8-30-15.1

1.2 The requisitioning organizations maintain adequate records to support the rationale for determining attrition quantities, based on the commodity type, commodity level, and pure quantity. The commodity attrition level is determined based on the following attrition level definitions:

- a. Low - For use on a follow-on program with existing technology and high manufacturing/test maturity.
- b. Average - For use on a new program with existing technology or a follow-on program with new technology of average manufacturing/test maturity.
- c. High - For use on a new program with complex technology and low manufacturing/test maturity.

1.3 For high reliability electronic components (Hi-Rel parts), the computer accessed database described in paragraph two (2) of this instruction may be used. If the database is used, attrition experience is maintained in the system. Requisitioning organizations must, however, maintain adequate records to support the rationale for determining the commodity attrition level.

*2. Hi-Rel Parts Attrition Factors

*2.1 The Product Operations and Materiel Directorate (POMD) maintains a database which is used to determine Hi-Rel attrition for proposals and for requisition generation. Attrition factors for each commodity attrition level are derived from the attrition consumption records in the inventory system for each of the following commodity types:

- | | |
|--------------------------|-----------------------|
| -Capacitors | -Integrated Circuits |
| -Coils | -Microwave Components |
| -Connectors | -Resistors |
| -RF Connectors | -Transistors |
| -Connector Pins/Contacts | -Transformers |
| -Diodes | -Miscellaneous Hi-Rel |
| -Hybrids | Commodities |

2.2 POMD reviews the Inventory System attrition data at least once each year and updates the attrition factors as necessary.

SPACE AND COMMUNICATIONS GROUP
MATERIEL INSTRUCTION

No 8-30-15.1

SUBJECT Material Attrition

2.3 When the database is computer accessed, it automatically calculates attrition quantities when the user supplies:

- a. Commodity type
- b. Commodity attrition level (low, average, or high)
- c. Pure quantity

2.4 The commodity attrition level is determined based upon the attrition level definitions shown in paragraph 1.2.

2.5 Additional quantities that may be required for radiation testing, destruct physical analysis, or acceptance or qualification testing cannot be calculated from this database.

2.6 The requisitioning organization maintains records adequate to support the rationale for any specific additional quantities required.

3. Attrition Application

3.1 Organizations requesting material include proper attrition quantities on acquisition documents.

3.2 Materials scrapped in Receiving, Inspection/Test (RIT) are closed to inventory when issued to attrition.

3.2 Quantities procured as attrition remain in Stores until required for replacement purposes. Materials issued to replace scrapped materials in the manufacturing/engineering/test cycles are issued as attrition. This transaction is accomplished by using the Stores Transaction form 11926, with the attrition box appropriately marked. The Stores Transaction form is also used to return unused attrition material to Stores.

3.4 Material issued to attrition, replacing damaged material must state on the document "for replacement" and give the using assembly number. Material issued to attrition to scrap material must state "scrap" on the Stores Transaction form.

3.5 This instruction must be adhered to for all new proposals and proposal updates and their resultant programs, and is to be implemented as soon as is feasible.

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Date: 03/30/90

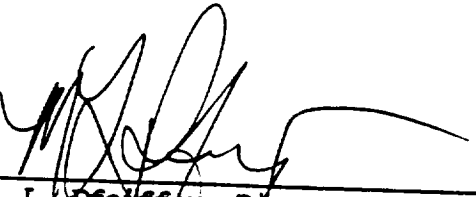
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SPACE AND COMMUNICATIONS GROUP
MATERIEL INSTRUCTION

SUBJECT Material Attrition

No
8-30-15.1Responsibility

4. The Director of POMD is responsible for implementing this Instruction within the Product Operations and Material Directorate, for maintaining a database to calculate attrition for Hi-Rel components, and for the periodic review and updating of attrition factors in the Hi-Rel Parts pricing system.
5. Operations Division Managers are responsible for implementing this Instruction within their respective divisions.



M. L. Pfeiffer, Director
Product Operations and Materiel

*Revision

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4.2 PERFORMANCE ASSURANCE PLAN

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HS256C-1045-0055

PERFORMANCE ASSURANCE PLAN

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1. GENERAL PROVISIONS

1.1 Basis and Scope

The provisions of this plan are based on and responsive to the requirements set forth in NASA/GSFC document GSFC-415-R-00004, Performance Assurance Requirements for General Instruments. It is intended to meet the applicable requirements of NASA reliability, quality assurance and EEE parts management Handbook NHB 5300.4 (1A, 1B and 1F). This plan establishes common hardware and software product assurance requirements with respect to safety, reliability, maintainability and quality for Hughes Aircraft Company's part in the design development, production, test and operation of the HIMSS instrument and its support equipment for the Earth Observing System (EOS).

This plan also defines expanded performance assurance in the areas of reviews, functional and environmental testing, contamination control, parts control, and materials control. It also complies to with applicable parts of WSMCR 127-1, "Range Safety Requirements, Range Safety Regulation", Western Space and Missile Center, and NASA Handbook NHB 1700.7.

1.2 General Requirements

Hughes will establish in accordance with the provisions of this plan, an organized program for demonstrating that the elements of the HIMSS instrument meet the functional requirements with specified margins, that the hardware has been manufactured properly and will operate properly in association with all other project components, and that the software meets design and mission requirements.

The performance assurance program that Hughes will implement and maintain through this plan will encompass flight and flight support equipment, government furnished property, and spares. The provisions of the program will apply to all work accomplished by Hughes and by any subcontractors and suppliers (also termed "contractors") engaged by Hughes to provide hardware, software or support services.

1.3 Performance Assurance Implementation Plan

This plan describes Hughes' system for accomplishing the performance assurance activities outlined in the performance assurance plan. Maximum use of existing Hughes practices and procedures shall be made in complying to the customer requirements.

This plan addresses each section of the requirements with detailed descriptions of how the requirements are accomplished. In addition, the plan includes:

- a. Organization chart and accompanying definition of responsibilities, presented in paragraph 1.5.
- b. A matrix cross-referencing GSFC415-R-0004 requirements to applicable plan paragraphs or sections, and to the procedures, instructions and specifications cited herein, presented as Appendix A.
- c. A list of assurance services that may be procured, identifying the proposed subcontractor, presented as TBD.
- d. Identification of significant hardware and software items to be purchased, and a description of the requirements of this plan that will be imposed on each item, presented as TBD.

A copy of each procedure and documented instruction is provided as part of this plan, presented as TBD.

1.4 Use of Previously Designed, Fabricated or Flown Hardware

Documentation substantiating previous designed, fabricated or flown hardware is presented as TBD of this plan.

1.5 Management of the Assurance Program

1.5.1 Organization

Hughes has structured the HIMSS program management organization (Figure 1-1) to ensure that the program performance assurance effort receives the maximum possible emphasis. The organization features, in accordance with Hughes' proven practice, the centralization of authority over all program activities in the office of a unique and dedicated program manager who is ultimately responsible for every aspect of Hughes' performance on the contract. Immediate cognizance over the product assurance program is assigned to the product assurance manager who will report directly not only to the program performance assurance manager but also to SCG's Product Assurance Directorate affording him direct access to the top management of all Company organizations participating on the program.

The structure retains the efficiency of Hughes' traditional program management scheme, in which the summary authority necessary to expeditious decision-making is vested in the program manager, but incorporates, without compromising that efficiency, a formal means of implementing Hughes' recognition of the critical role of the program product assurance activities and the explicit attention their extensive scope demands. Hughes recognizes, for example, the near-inevitability of a program as complex as HIMSS of occasional conflicts among performing organizations for available program resources: the summary authority of the program manager permits the timely resolution of such conflicts, while the organizational

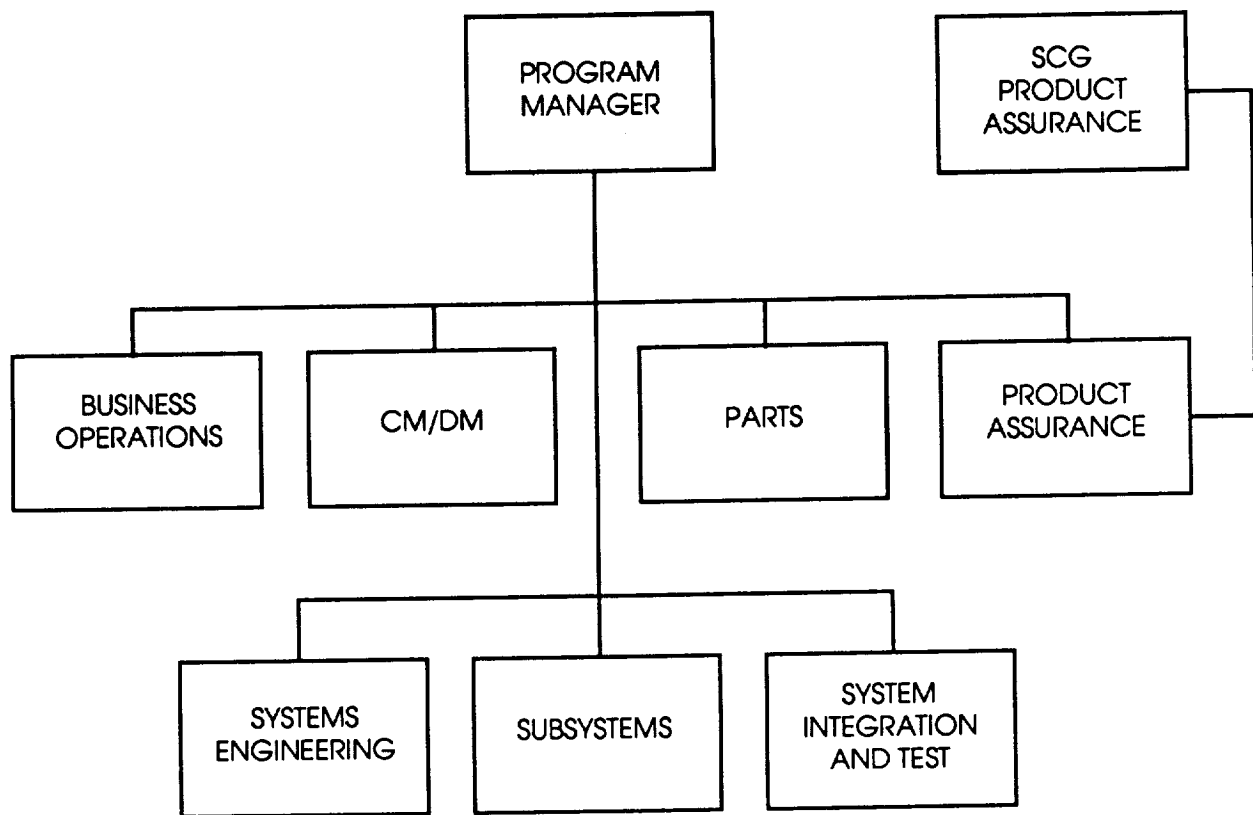


FIGURE 1-1. HIMSS PROGRAM MANAGEMENT ORGANIZATION

prominence of the manager charged with product assurance responsibility ensures that the demands of meeting requirements in this area are adequately represented and fully reviewed at the highest possible level within the program and within Hughes Aircraft Company.

Functionally the HIMSS performance assurance organization (Figure 1-2) will have cognizance over the full range of program product assurance activities: reliability, quality assurance, materials and processes control, system safety, contamination control, parts control, flight assurance reviews, and performance verification. Structurally, it will consist of independent offices through which these diverse activities will be administered as three basic functions:

Product Assurance, comprising the activities of reliability and quality assurance, materials, and processes control, system safety implementation and contamination control

Parts, comprising the activities of material logistics and component engineering support, and two special activities dedicated to surveying the sensitive areas of hybrids and special components production/procurement (see 1.5.3)

Verification, comprising the activities of performance verification, flight assurance reviews, and reliability analysis

The Parts and Verification activities will be directed by a manager who will report directly to the product assurance manager. The HIMSS systems engineering manager will be responsible for directing the program verification effort. The program product assurance manager will be assigned from the SCG Product Assurance Directorate.

1.5.2 Product Assurance Management

A program product assurance manager vested with the authority delegated that office of the Product Assurance Directorate shall be assigned to the program office and shall be responsible for implementing and managing this product assurance program. As an integral member of both the program management team and Hughes Space and Communications Group's Product Assurance Directorate, he shall have the direct, independent, and unimpeded access to top management shown in Figure TBD. It shall be his responsibility to implement management procedures and establish command media requirements that ensure the product assurance disciplines are effectively utilized in the design, procurement, manufacturing, and test activities. His authority is derived from Hughes Management Directives, which establish responsibilities and guidelines for implementation of the product assurance discipline.

The program product assurance manager's staff shall include

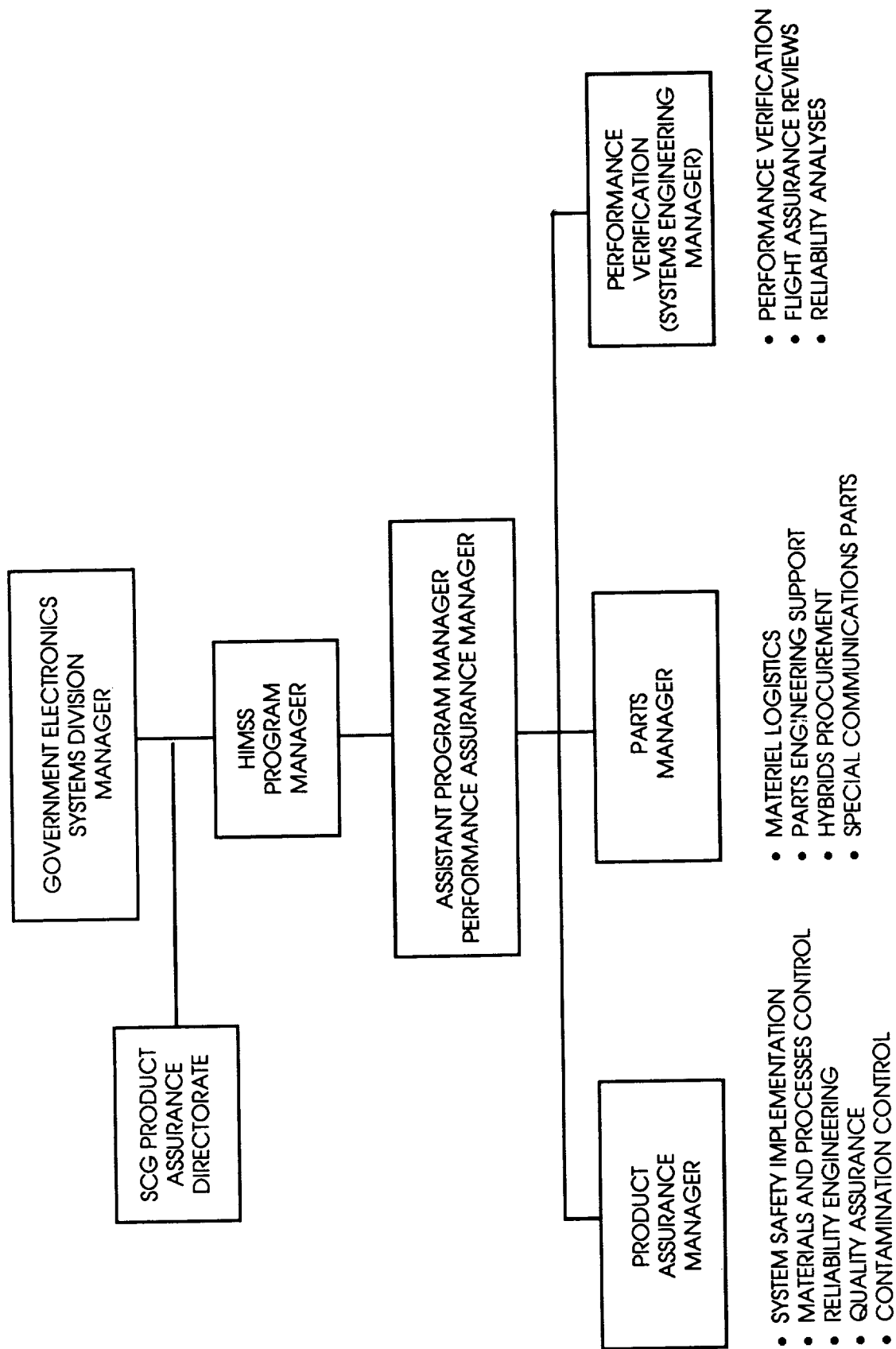


FIGURE 1-2. HIMSS PERFORMANCE ASSURANCE ORGANIZATION

specialists required to ensure that program product assurance requirements are appropriately implemented. The program product assurance manager shall participate in significant program engineering and management meetings and reviews to keep current with the overall progress of the program. He shall be responsible for ensuring immediate attention to and resolution of any situation that appears to jeopardize the achievement of product assurance objectives and the requirements of this plan.

1.6 Performance Assurance Status Report

Descriptions of the performance assurance program status will be submitted weekly to Hughes management and their contents summarized in a monthly report Hughes will submit to the customer as the project Performance Assurance Status Report. These monthly reports will include:

- a. A description of significant problems encountered in implementing performance assurance activities,
- b. Notice of any key organization or personnel changes,
- c. Identification and description of any unresolved hazards disclosed by the safety program, and notice of the action taken or contemplated to eliminate such hazards,
- d. A review of the significant analyses, inspection and test activities conducted,
- e. A description of the status of procurement and of subcontractor performance,
- f. A summary of all program audit reports
- g. Results of alert surveys that directly effect the HIMSS program.

The Performance Assurance Status Report will also address any other items cited for inclusion in the individual sections of this plan.

1.7 Surveillance of Hughes' Performance

Hughes will take all measures necessary to accommodate and facilitate the evaluation, review, and survey, by government designated representatives, of the work, activities, and operations performed on the HIMSS program by Hughes or by Hughes subcontractor and suppliers. Hughes understands that such government designated representatives may include personnel from the GSFC project office, the Government Inspection Agency (GIA), or an independent assurance contractor (IAC) engaged by GSFC.

To facilitate such review and evaluation, Hughes will provide the government designated representatives with the documents (including an approved Performance Assurance implementation Plan), records, equipment, and working areas within Hughes facilitate that they require to perform these overview activities.

Whenever Hughes inspects subcontractor/supplier facilities and activities, Hughes will provide the government designated quality assurance representative located at Hughes with a list of the duties, responsibilities, and authorities of the Hughes quality assurance personnel who will conduct the review at the source site. Whenever both Hughes and government source inspection personnel visit any supplier facility, Hughes will provide a like list to the government source representative located at that facility, upon issuance of the procurement. At no time will government source inspection be used in lieu of Hughes source inspection.

1.8 General Procurement Procedures

Hughes will assign qualified assurance personnel to participate in selection of its procurement sources on the HIMSS program. All Hughes procurement sources are chosen on the basis of performance history, receiving inspection and test results, survey results and supplier rating system.

The HIMSS product assurance manager shall ensure that the procurement documentation includes appropriate program product assurance requirements. This shall be accomplished by issuing command media that reflects program product assurance requirement, approval of specifications, and statements of work issued to major subcontractors. Product assurance audits shall be performed to ensure compliance with established requirements.

Product assurance requirements of vendors and suppliers shall be flowed down by each quality organization, who shall be directly responsible for ensuring compliance of all delivered articles with applicable procurement requirements.

The HIMSS Program Parts, Materials, and Processes Control Board shall be responsible for ensuring that EEE parts meet the requirements of this plan. The Control Board shall interface directly with the responsible engineers and operations division quality assurance to establish appropriate requirements for source surveillance and receiving inspection and test. The operations division quality assurance manager shall make assignments to perform inspections and monitor supplier activities to ensure compliance. The Control Board shall be responsible for final resolution of problems which involve conformance of EEE parts to program requirements.

Each operations division quality assurance organization shall

be responsible for ensuring that required quality provisions are applied during procurement of materials and fabricated items. Adequate quality support shall be provided to allow implementation of applicable program requirements. Supplier performance shall be audited to establish and maintain an acceptable vendor quality rating for the item procured. Source inspections and/or receiving inspections shall be performed to the degree necessary to ensure that critical drawing and specification requirements are met.

Each subcontractor plan shall be reviewed and approved by both the cognizant operations division quality assurance manager and the program product assurance manager to ensure compliance with program requirements. Subcontract plans shall clearly identify the subcontractors organization and its interface with other activities. Source engineers shall survey subcontractor operations, perform mandatory inspections, identify potential problems for resolution, and report the status of subcontractor activities to the program office. Documentation requirements shall be controlled by specific subcontractor data requirements lists (SCDRLs). Survey results shall be evaluated and where appropriate, utilized during follow-up audits of subcontractor to ensure proper action.

1.9 Audits

Hughes will conduct a comprehensive audit of the performance assurance activities of both Hughes and its subcontractors/suppliers to ensure compliance with the provisions of this plan and the procurement documentation cited herein. Each such audit will include an examination of operations and documents as well as an examination of articles and materials.

The HIMSS performance assurance auditing program will be conducted within the framework of Hughes SCG's formal quality auditing system, which is both comprehensive and complete, comprising both formal and informal (scheduled and unscheduled) audits at both the Group and program levels. At the Group level, internal audits of the activities of performing line organizations (e.g., Product Operations, or manufacturing) are performed at least annually at the direction of the SCG Product Assurance Director. These formal audits are conducted to ensure such organizations are complying with the governing Hughes command media by the Quality Engineering Organization, reporting to the SCG Product Assurance Directorate.

1.9.1 Subcontractors and Suppliers Audit

Hughes will audit the performance assurance activities of each of the subcontractors/suppliers it engages on the HIMSS program as necessary to ensure their compliance with the performance assurance requirements imposed on them by the provisions of this plan and its applicable documents. Hughes' schedule for the performance of such auditing, and the content of such audits, will be based on:

- 1) The criticality of the items being procured, as determined failure modes, effects, and criticality analyses or information generated by trend analyses
- 2) Known problems or difficulties regarding the procured items
- 3) Suppliers quality histories
- 4) The remaining period of supplier performance

This auditing program has the same structure as Hughes' internal assurance auditing program, i.e., it comprises both 1) program level audits conducted under the direction of the program quality engineer and 2) the independent group level auditing of Hughes subcontractors performed by SCG Product Assurance Directorate personnel in support of company procurement efforts.

1.9.2 Audit Reports

Hughes will submit documented accounts of all HIMSS program performance assurance audits conducted, including audits of engaged subcontractors and suppliers, to program management, and will include in such reports recommendations for correcting any deficiencies noted. Program management will take action to ensure the correction of such deficiencies and conduct reviews to ensure the corrections have been made.

Specifically, the HIMSS program quality engineer charged with responsibility for conducting these audits will summarize his findings in reports submitted to the program product assurance manager, performance assurance manager, and HIMSS program manager. The HIMSS program manager will report these findings to the Group Executive. These reports will all be made available to the resident government representative on request, and their content will be summarized and included in the Performance Assurance Status Report the Hughes will submit to NASA/GSFC as noted in 1.6 of this plan.

1.10 Applicable Documents (Appendix A)

In addition to applicable documents listed in GSFC-415-R-00004 Appendix A, the following Hughes SCG documents in effect as of the date of contract form a part of this plan to the extent referenced herein:

<u>HUGHES DOCUMENT NO.</u>	<u>TITLE</u>
TBD	TBD

1.11 Glossary (Appendix B)

Hughes performance assurance documentation will assume the definitions of terms presented in GSFC-415-R-00004 Appendix B.

1.12 Deliverable Data

Hughes will deliver all documentation cited as deliverable as prescribed by GSFC-415-R-00004 Appendix A.

2. ASSURANCE REVIEW PLAN

2.1 General Provisions

Hughes System Engineering personnel assigned to the HIMSS program office are responsible for supporting the assurance review program as described in the Assurance Review Plan submitted with this plan.

Program product assurance and quality assurance will participate throughout the assurance review program as described in this plan.

3. PERFORMANCE VERIFICATION PLAN

3.1 General Provisions

Hughes will make maximum use of proven, existing practices and procedures to meet documentation requirements of the performance verification program. The HIMSS system engineering organization will prepare subsystem specifications based on an analysis of the system performance requirements and for each subsystem will allocate functional requirements chosen to ensure that the system requirements are achieved. In addition, for each functional requirement cited in the subsystem specifications, a verification requirement will be specified. In general, verification by test, analysis or inspection will be required.

The HIMSS system engineering organization will be responsible for the preparation and maintenance of the verification plan to be submitted along with this plan.

4. SYSTEM SAFETY

4.1 General Provisions

This section defines the systems and procedures that will be used by Hughes to implement the system safety requirements of GSFC 415-R-00004. The safety program provisions will be implemented throughout the design, development, assembly, integration, test and launch phases of the program.

4.1.1 Objectives

The objectives of the system safety effort are as follows:

- 1) To ensure safety is designed into the system and is maintained throughout design, manufacture, assembly, test, storage, transportation, launch site operations, orbital operations, landing and post-landing.
- 2) To ensure operational control over identified hazards is established to protect personnel, equipment and property.
- 3) To ensure safety requirements are cited in procurement and design specifications, manufacturing, test, and operational plans and procedures.
- 4) To ensure malfunctions of equipment or operator errors will not result in injury to personnel or damage to equipment, facilities, or property, thus minimizing delay, rework, retest and cost.
- 5) To ensure effective measures are taken to reduce the possibility of accidents or incidents that could result in injury, death, or property damage.
- 6) To ensure control of any payload hazard to provide safe operation with minimum dependence on launch support personnel or the orbiter crew for safing actions.
- 7) To assign responsibilities for compliance with specific safety requirements of the program.
- 8) To ensure a system of follow-up of corrective actions.
- 9) To establish an accident reporting and investigation procedure.

4.1.2 Safety Effort

The system safety engineer will ensure that procedures, equipment and material to be used on the program are reviewed to identify conditions or events that may result in a hazardous

environment. The system safety engineer will provide input to the corporate health and safety officer to ensure a safe environment for all HIMSS personnel.

4.2 Subcontractors and Suppliers

Subcontractors and suppliers whose efforts can have significant impact on system safety will be required to meet the program safety requirements as noted in this plan's Reliability Requirements for Subcontractors and PA8007 System Safety Requirements for Subcontractors. Liaison will be maintained with subcontractors and suppliers to ensure that procedures are established to integrate their safety efforts into the overall safety program.

5. EEE PARTS CONTROL PLAN

5.1 General Provisions

Hughes will implement and maintain a comprehensive program for the selection and control of electrical, electronic, and electromechanical (EEE) parts. This program will be administered by a dedicated parts manager working in conjunction with the program product assurance organization.

The parts program will implement a means of assuring early detection of parts problems. This aspect of the parts program will have three components:

- 1) A strong parts selection and screening program of the suppliers.
- 2) Evaluation at Hughes of each lot of parts for defects upon receipt and prior to manufacturing.
- 3) Performance of special lot screening and tests to provide additional assurance of the reliability of the parts.

Hughes Material Control will be responsible for handling and storage of parts from Hughes Receiving until they are placed in kits for fabrication. Parts management team personnel will establish handling and packaging criteria and maintain status and traceability.

Electronic parts will be individually packaged. When it is necessary to remove parts from the package for electrical test, they will be repackaged and placed in plastic bags or containers for protection.

Parts will be placed in controlled storerooms that have limited access and are program related. Fabricated parts will be placed into containers or protective bags prior to entering the storeroom. Specific precautions will be taken to protect critical parts with appropriate packaging which provides protection from handling, electrostatic discharge, or corrosion damage. Within the storeroom, adequacy of the packaging, handling, and storage techniques will be monitored by quality assurance. Parts/subassemblies will be accumulated into assembly of kits within the storeroom prior to issue to the next operation. Completed assemblies will be placed into protective bags or containers prior to entering the storerooms. Components issued will not be removed from their protective containers until ready for installation.

5.2 Order of Parts Selection

Emphasis will be placed on parts selection and usage to ensure that only parts capable of meeting the operational and environmental

requirements are used and that the number of types is kept to a minimum. Parts will be selected from the following sources in the order of priority listed:

- 1) MIL-STD-975 (NASA) Standard Parts List
- 2) GSFC PPL (for parts not covered in MIL-STD-975) Grade 1
- 3) Contractor's Parts Selection Guide for Space Programs (PAI 403)

Parts selected from sources other than Grade 1 parts in MIL-STD-975 and the GSFC PPL will require GSFC review as nonstandard parts (see section 5.4).

5.2.1 Critical Applications

Standard Grade 1 parts as described in the GSFC Preferred Parts List (PPL), MIL-STD-975 and NHB 5300.4(1F) shall be selected for critical applications as defined in GSFC-415-R-00004 paragraph 5.2.1 wherever possible. If a nonstandard part has to be used in a critical application, it will be specified to requirements similar to those for the nearest standard Grade 1 part.

5.2.2 Noncritical Applications

As in critical applications, standard Grade I shall be selected wherever there is a listing in MIL-STD-975. Standard Grade 2 parts will be used only if MIL-STD-975 does not list a Grade 1 part. Nonstandard parts selection will be specified to requirements similar to those for the nearest Grade 1 or Grade 2 part.

5.3 Parts Categories, Application and Controls

5.3.1 Standard Parts

Standard parts, as described in the preceding paragraph, shall be procured in accordance with the specification designated for the part and from the approved sources of the specification. If procurement from the approved source is not possible, the part will be considered a nonstandard part, and treated accordingly.

5.3.2 Nonstandard Parts

Nonstandard parts, as defined in GSFC-415-R-00004 paragraph 5.3.2 shall be reviewed and controlled in accordance with paragraph 5.4 of this plan.

5.3.3 Parts Derating

Parts derating requirements for circuit applications will conform to Hughes SCG PAI 303 which implements the intent of

Appendix A of MIL-STD-975 or Appendix B of the GSFC PPL 16 (for parts not covered by MIL-STD-975). Use of parts in the RESTRICTED regions identified in PAI 303 will be prohibited. All parts applications which fall into the APPROVAL REQUIRED regions identified in PAI 303 will be presented at the CDR. A report showing the derating used for each part will be provided. Reliability and parts management personnel will work closely with the responsible engineering activities which will avoid parts that exceed the derating policy. This analysis will be documented on schematic drawings or special derating analysis forms.

5.3.4 Radiation Hardness

Parts radiation degradation data have been compiled by Hughes for radiation-sensitive parts listed in the Hughes Component Parts Selection Guide. These parts will be shown on the Approved Parts List (APL), as being radiation tolerance approved. New semiconductor parts selected for HIMSS will be evaluated for their radiation sensitivity and will be tested if required. Hughes will perform lot-to-lot sample testing on parts when experience indicates radiation susceptibility to be lot dependent. In addition, sample lot screening test will be performed as necessary on semiconductor parts that may have had recent processing or manufacturing changes.

These data will provide an estimate of the upper bound radiation levels to be encountered at the piece part level to determine the effect on circuit performance. Parts found by analysis to have marginal or inadequate performance at end of life will be subjected to radiation hardening techniques. These techniques include circuit redesign, sensitive component replacement, electronics location, and piece part and box shielding. Results of these assignments will be presented at the Critical Design Review.

5.3.5 Screening Verification Tests

All parts will be screened by their manufacturer or independent test laboratory to the electrical, mechanical, and visual requirements of their procurement specification. These requirements will be no less stringent than those in Appendix C of GSFC PPL and will prescribe test methods and conditions, failure criteria (drift and limit), and lot rejection criteria. In addition, internal visual inspection will be performed by Hughes on all semiconductors (including microcircuits and hybrids) and any other complex parts (relays, magnetics, TCXOs, etc) whose internal condition and quality cannot be definitively established by receiving inspection techniques.

The high reliability parts screening requirements to be used on this program for approved parts listed in the project APL, other than MIL-STD-975 or GSFC PPL parts, are summarized in Table 5-1. Specific requirements are contained in the general procurement

specifications for each generic family and the detailed parts standard for each part type. Screening test results will be reviewed by Hughes for compliance to specification requirements.

Nondestructive screening tests listed in Table 5-1 are described as follows:

1) Internal Visual Inspection - An internal visual inspection (precap) for contamination and construction anomalies will be made. For lidded devices such as microcircuits, a precap visual inspection will be performed at an appropriate magnification to allow detection of such defects as inadequate bonds, smeared interconnections, and particulate contamination. Acceptance criteria will be specified for each part type. Rejected parts will be removed from the lot.

2) High Temperature Reverse Bias - A high temperature reverse bias test will be specified on all pnp transistors. Parameters will be defined in the component specification and will include beta and leakage current measurements.

3) X-ray Inspection - X-ray inspection is required that have internal construction that will allow meaningful X-ray examination. Inspection is made with the assistance of image magnification through photographic enlargement, projection, or examination through a microscope. Acceptance criteria for each part is specified. X-ray specimens will be correlatable to the film image to allow identification of each part to its X-ray image. Rejected parts are removed from the lot.

4) Temperature Cycling - Temperature cycling is specified as a prescreening test. Five complete cycles are performed between maximum and minimum storage temperature of the part. Semiconductors and microcircuits are subjected to 10 complete cycles.

5) High Temperature Storage - A high temperature storage test at the maximum specified storage temperature of the part is performed for semiconductors and microcircuit devices.

6) Seal Test - A fine and gross leak test is performed on hermetically sealed components.

7) Acceleration - Acceleration in a direction perpendicular to the bond surface is required to semiconductors. The acceleration level specified in the detail specification will be selected to assure adequate bonding.

8) Noise - Carbon composition resistors are measured for noise using MIL-STD-202, Method 308. Part and lot acceptance criteria are specified.

9) Acoustic Vibration - A nonoperating particle impact noise detection (PIND) test during low level vibration will be performed on all cavity part types either by the vendor or at receiving inspection. Devices subject to damage by this test may be exempted from the test (reference MIL-STD-883 Method 2020).

10) Burn-in - In addition to prescreening tests as specified in the applicable procurement specification or source control drawing, parts will be placed on burn-in for the minimum period specified in Table 5-1. The critical electrical parameters are recorded at specific intervals and data examined for stability of parameters. Lot rejection criteria (i.e., percent defective allowable) are specified for each generic part type. Hughes may elect to extend the burn-in period to further assure stability of parameters.

11) Scanning Electron Microscope - Microcircuits and selected semiconductor devices will be selected from wafers that are acceptable based on the requirements of MIL-STD-183, Method 2018 or MIL-STD-750, Method 2077, scanning electron microscope examination of metallization.

Screening specifications will be prepared for rescreening approved JANTX or JANTXV transistors and ceramic capacitors. The rescreening program will be based on the requirements of MIL-STD-975. Other approved parts that are normally screened by the manufacturer need not be rescreened unless incoming inspection results, construction analysis results, ALERTs, or other factors such as special design drift tolerances indicate the need for such rescreening. As an alternative to rescreening ceramic capacitors, they will be procured to Hughes General Specification 908000 or SRAB.

Incoming inspection will be performed on procured parts to verify continued conformance to the requirements of the controlling documentation. Inspection will include verification of visual, mechanical, and electrical characteristics. Additional inspection will be conducted as program experience indicates is necessary. Incoming inspection will include the following:

- 1) Review of data shipped with parts for compliance
- 2) Part count and traceability
- 3) Inspection of part markings and external defects
- 4) Dimensional check
- 5) Electrical measurement of critical parameters on a sample basis: verification of vendor's test program and burn-in test results on a selected basis may be used in lieu of receiving tests

5.3.6 Destructive Physical Analysis

Hughes will perform a destructive physical analysis (DPA) on samples for each lot of specific generic part types included in the screening matrix. This includes semiconductors, microcircuits, crystals, and relays. The sample quantity and degree of analysis will be based on experience with the specific manufacturer and generic part types. Lot quality verification includes both construction analysis and sufficient electrical testing to maintain the qualification status of incoming parts. Lot quality verification plans and procedures define the methods of lot accept/reject criteria for inspecting part design, materials, and workmanship. These samples will be evaluated by external and internal examination to ensure that the vendors maintain the necessary in-process controls, verify the effectiveness of the precap visual inspection and preconditioning, and verify uniformity of the vendor's product.

The destructive physical analysis will include an examination and inspection of the internal construction of the device as performed with an optical microscope and a scanning electron microscope on microcircuits and transistors. The criteria for the optical examination will be the requirements for precap visual inspection as specified in the applicable procurement document. The scanning electron microscope examination will be in accordance with MIL-STD-883, Method 2018 or MIL-STD-750, Method 2077, as applicable. In addition, the overall interior of the package will be examined for workmanship defects, foreign material, and any other anomalies that might interfere with the normal application of the device or otherwise present reliability hazards. Bond pull testing will be performed on semiconductors having internal bonding wire. The inspection will be sufficient to describe and identify salient construction features of the devices, such as the metallization system, bonding technique, die-attach method, and surface passivation. The sampling plan will be as follows:

- 1) A sample of five parts will be pulled from each manufacturing lot and delivered to the DPA laboratory.
- 2) The laboratory will perform the required analysis on three of the parts.
- 3) The remaining two parts will be held with the DPA parts as representative samples of that lot, for any future investigations required.

The analysis will be reviewed to provide assistance of early detection of potential lot related problems. The review will be performed by the Destructive Physical Analysis Board, chaired by the program product assurance manager, and composed of the program parts manager and representatives from the Quality Engineering organization, Technology Division support specialists, and the

Hughes SCG Product Assurance Directorate. Analysis results will be used as a basis of acceptance or rejection of part lots for flight equipment. Minutes of the board meeting will indicate acceptance or rejection of each lot.

The Hughes destructive physical analysis procedures meet the requirements of GSFC Specification GSFC-S-311-70. These procedures will be submitted to GSFC.

5.3.7 Screening for Particulate Contamination

Screening for particulate contamination will be performed in accordance with paragraph 5.3.5 note 9 and Table 5-1 of this plan.

5.4 Parts, Materials, and Processes Control Board

The program Parts, Materials, and Processes Control Board (PMPCB) will act to approve or disapprove all parts as they are selected and identified. New parts not listed in the selection lists that may be necessary to meet the design specification for this procurement will be submitted by the responsible engineering activity (REA) to the PMPCB to ascertain whether the particular need can be filled by an already approved item. Should further investigation be necessary, a team will be assigned to investigate the engineering requirements in detail.

Members of the Board will include the program performance product assurance, and parts managers, and representatives from the Components Engineering System Laboratories (CESL), system engineering, and the requesting engineering organizations as required to support the review activities. The Board will be chaired by the product assurance manager or his designee. Approval by the Board Chairman of the particular part will constitute authority for its use in the system.

Any part not listed as Grade 1 in MIL-STD-975 or the GSFC PPL will be considered a nonstandard part. The use of nonstandard parts will be controlled and require submittal and GSFC review/concur of a NSPAR. Submittal of NSPAR will be through the use of GSFC Form 4-15, GSFC Nonstandard Parts Approval Request, or an approved and fully equivalent Hughes format. Hughes control and approval of nonstandard parts will be accomplished in the following manner:

- 1) Hughes will provide NASA/GSFC with a request for addition of a new nonstandard part to the APL 5 working days prior to addition. Each request will be accompanied by a documented justification of the HIMSS program requirement for the nonstandard part use. GSFC will review and comment to Hughes. If the GSFC part review uncovers any adverse history pertaining to performance or reliability affecting the proposed application, the GSFC commentary will be acted upon by the PMPCB and the Responsible

Engineering Activity (REA), to take corrective action, initiate investigation by the REA for selection of an alternate part, or otherwise demonstrate that the performance and reliability are consistent with the program requirements. Subsequent addition of a part to the APL will be coded in the approval column as "approval pending".

- 2) The program PMPCB will initiate NSPAR, GSFC form 4-15 (1/70) activity by authorizing preparation of a new specification, if required, and investigation of the proposed basis of qualification for the new part.
- 3) The PMPCB will review all new specifications for completeness of content including performance as well as reliability and quality assurance requirements. Concurrently, a copy of the specification will be forwarded to GSFC for their informal review and commentary. The Board will also review and approve the proposed basis of qualification and any qualification test plans as required.
- 4) After compiling, reviewing, and recommending approval of all documentation required for the NSPAR, the Board will request Program Management review and approval of the proposed submission. The NSPAR will show the PMPCB approval and approval date.
- 5) The NSPAR for each nonstandard part approved by Hughes will be submitted to GSFC for review within 10 working days of final Hughes approval action.
- 6) GSFC will complete their review and submit their recommended concurrence or nonconcurrence. A GSFC nonconcur will indicate specific contractual requirements which are not satisfied.
- 7) In the case of a GSFC nonconcur, Hughes will take corrective action or otherwise demonstrate the indicated requirement is satisfied. The parts designated nonconcur by GSFC shall be so designated on the APL until issue is resolved or the part removed from the APL. Documentation of Hughes' response to the nonconcur will be submitted to GSFC 5 working days prior to the classification of the part as approved or provisionally approved in the case of a qualification test plan submission. After qualification testing is complete, the NSPAR will follow Items 4 through 7 herein.

Failure analysis will be conducted on all parts failing after incorporation into flight hardware (unless the failure was induced) or during part qualification tests. The failure analysis reports

will disclose the cause of the part failure, the failure mechanism and mode, the extent of the problem, and the remedial action required. These analyses will be suitably identified in the flight hardware report or part qualification report and readily available to GSFC. Where appropriate, these analyses shall be attached to the failure report.

The program PMPCB will participate in investigating and devising remedial and preventive action for each part that causes a nonconformance in a higher level of assembly.

The significance of each failure to like parts elsewhere in the system, the possibility of occurrence of additional failures, and actions taken to eliminate these concerns will be determined, documented, and provided to the NASA on-site representative.

5.5 Parts Identification List

Hughes and its subcontractors providing complex or mission critical hardware will prepare and maintain a project parts list to use in design of the contract hardware. Hughes has prepared and submitted an Authorization Parts List (APL) containing all part types (DRL 404-01) used in HIMSS hardware including subcontracted hardware. An update will be provided 90 days after award of contract on GSFC form 300-22(2/TL) (see Figure 5-1). Because these items are a limiting factor on the reliability of design and hardware, every effort will be made to select and qualify all necessary parts as early in the project life as possible. The initial project parts will be submitted to the procuring NASA installation prior to initiation of detailed design of the hardware. The list will include Hughes part name, nearest equivalent commercial or military designation, standard or nonstandard classification status, and submittal revision. The listing will identify those parts approved by GSFC and show nonstandard part approval status on parts still to be approved. The list will be kept current, and parts that are disapproved or no longer planned for use will be deleted. Copies of each parts list revision will be provided by GSFC. Request for additions to the APL shall be provided to the GSFC representative 5 working days prior to addition of parts to the APL.

6. MATERIALS AND PROCESSES

6.1 General Provisions

The program product assurance manager will direct the planning and execution of a comprehensive materials and processes control program for the HIMSS effort. He will direct and coordinate all materials engineering tasks, act as a direct interface between materials specialists and the responsible design organization, control funding, and report the status of these activities to the HIMSS program manager.

6.2 Materials Selection

Materials will be selected to withstand all specified environments. In particular, materials will be selected which will pose minimum risk to the mission with regard to materials outgassing. Hughes will use as its basic guide to outgassing characteristics of organic and polymeric materials NASA RF 1124, Outgassing Data for selecting Spacecraft Materials. Hughes will pay particular attention to the currentness of data, qualification basis, and the adequacy of specifications. Materials application engineers will thoroughly review each production drawing to ensure appropriate selection and proper application of materials and processes and will devote special attention to outgassing characteristics. All production drawings and subsequent changes will be signed by the materials application engineer prior to release. In addition, materials used in contact with flight hardware (e.g., shipping containers, ancillary test, and support hardware) will be carefully selected to avoid contaminating the instrument.

Radiation tolerance of materials will be carefully examined to assure the use of only those materials capable of reliable performance in the anticipated mission environment.

6.2.1 Conventional Applications

Requirements for materials used in flight hardware and processes used in fabricating flight hardware will be covered by appropriate federal, military, Hughes standard or industry specifications. Detailed manufacturing processes will be covered by production fabrication instructions. Applicable documents listed in GSFC 415-R-0004. Appendix A, Section 6 will be utilized.

6.2.2 Nonconventional Applications

Where adequate specifications do not exist for materials and processes not used in the past, Hughes will prepare them. The Hughes materials and processes specifications include testing of material or process characteristics, quality assurance provisions, and test procedures that must be used. Batch sample testing and/or

end item testing to verify characteristics forms a part of each specification covering the fabrication of critical hardware.

6.2.3 Special Problem Areas

Hughes will give special attention to problem areas such as radiation effects, stress/corrosion cracking, galvanic corrosion, hydrogen embrittlement, lubrication, contamination of cooled detectors, and weld-heat-affected zones. Critical high strength fasteners and pressurized systems will be reviewed from a fracture mechanics viewpoint before they are accepted for use.

6.2.4 Organic Materials

Materials used will be noncombustible or self-extinguishing and shall not generate toxic vapors. The outgassing characteristics of organic materials with a total mass loss (TML) of less than 1.00 percent and a collected volatile condensable material (CVCM) of less than 0.10 percent, when tested in accordance with Appendix B of ASTM E595-77, will be used.

6.2.5 Inorganic Materials

Hughes shall use the criteria specified in MSFC-SPEC-522 to select metallic materials to control stress corrosion cracking. Those materials that do not meet the criteria shall be identified. If utilization of any noncompliant material is required, a usage request will be submitted via the Material Usage Agreement/Stress Corrosion Evaluation Form per MSFC-SPEC-522.

6.2.6 Considerations in Process Selection

Manufacturing processes are carefully selected to assure that they do not substantially change a material's properties particularly in the cases of heat treatment, welding, or chemical or metallic coatings. The objectives are to maintain the integrity of the materials and to avoid introducing property changes that could cause adverse effects.

6.2.7 Shelf Life Controlled Items

In processes that involve polymeric materials whose uncured constituents have a limited shelf life (as indicated by the manufacturer's literature), some latitude will be granted for the use of date-coded expired materials if certain requirements are met. Hughes will provide data to GSFC resulting from appropriate tests to ensure the properties of the materials have not been compromised for their intended use. The data from the tests will be submitted to GSFC prior to application. Fabricated items such as "O" rings that have out-of-date codes will not be installed in flight hardware.

6.3 Materials Review

To ensure proper application of materials, Hughes will conduct thorough materials applications reviews on each unit. The application of each material will be examined in light of its rated capabilities in comparison to the design requirements of that application. In ascertaining application adequacy, consideration will be given to anticipated life requirements, functional and environmental usage stresses, and historic and current failure experience. To implement this requirement, the program manager will issue a directive (Program Instruction) requiring adherence to the program authorized materials list and selection, and application requirement contained herein and in related documents.

Materials engineers will support each design activity in the section, specification, application, and testing of materials. Materials application review will be accomplished by a thorough drawing review by materials specialists. Each drawing will be reviewed for the correct materials designation and application and each item shall be checked for compliance with the Authorized Materials and Processes List. All drawings will be reviewed and signed by the materials engineer prior to release. The materials engineers will retain a record of the results of these reviews and will prepare a materials application review report for each unit to be included in the data package for the Critical Design Review.

6.4 Materials Documentation

Those materials and processes Hughes has found to be acceptable and preferred for use in the space environment are described in the Materials and Processes Selection Guide, Hughes PAI TBD. An Authorized Materials and Process List (AMPL) will be prepared to include all materials and processes used in the design and fabrication of flight hardware, including those complex or mission critical hardware on subcontract. Every effort will be made to ensure that materials application engineers select and qualify all necessary materials and processes as early as possible in the design cycle. It is expected that few materials and processes will require qualification since the majority have been used on prior STS launched spacecraft.

Compilation of the Materials and Process List, will be guided by the information on the following GSFC Forms: 18-59A, GSFC Spacecraft Inorganic Materials List 18-59B, GSFC Spacecraft Polymeric Materials List 18-59C, GSFC Spacecraft Lubrication List and 18-59D, GSFC Spacecraft Materials Process List. Each candidate addition to the list thereafter will be submitted via the GSFC forms for Government review prior to use. Hughes may elect to proceed with procurement/manufacture once approved by the PMPCB. If the GSFC review indicates specific contractual requirements not satisfied by the use of the item, Hughes will take corrective action or otherwise demonstrate that the requirement is satisfied.

The AMPL will be updated periodically to ensure currency and the current list will be submitted with the data package for the critical design review, pre-environmental reviews, and flight readiness reviews.

7. DESIGN ASSURANCE AND RELIABILITY PROGRAM

7.1 General Provisions

Hughes shall conduct a design assurance and reliability program in accordance with this implementation plan to ensure that the requirements of the technical specifications are met during all phases of the program.

Activity during the design and development process shall consist primarily of determining HIMSS instrument reliability and lifetime characteristics by performing analyses, participating in design reviews, and making reliability assessments. Activity during the manufacturing phase shall consist primarily of identifying, analyzing, reporting, and correcting failures.

Hughes will use trained personnel to implement the reliability program. Additional training and indoctrination in technologies and techniques peculiar to the program will be provided where required.

7.2 Design Assurance

To provide for adequate program design assurance governing engineering documentation applicable to design, procurement, and test will be subject to reliability review. Hughes will prepare a design specification for each subsystem which will detail the subsystem requirements. These specifications will include:

- 1) Applicable component level parameters as necessary to assure in-specification performance of HIMSS instrument.
- 2) Definition of the interfaces with other subsystems
- 3) Functional and environmental requirements
- 4) Test requirements
- 5) Safety margins and derating factors where appropriate and unacceptable failure effects
- 6) Physical parameters and constraints

Statements of work and equipment specifications will also be prepared. Design specifications will be generated early in the design process and updated to reflect refinement and changes. These specifications will provide a baseline for design of the system, its subsystems, and the instruments.

The program product assurance manager or his designee will review for concurrence all design specifications prior to release. This review will ensure that each specification 1) covers all items of hardware at appropriate levels; 2) is complete in content;

3) is consistent with interface specifications; 4) adheres to parts, materials, and processes requirements, when applicable, and 5) includes provisions for obtaining and recording data required to establish conformance to contract requirements. In addition, such a review will verify that specified criteria preserve inherent reliability. Independent review of these specifications will be conducted prior to the Critical Design Review (CDR). Results of the specification reviews will be summarized for the Critical Design Review and included in program status reports.

Design specifications, though generated by the design and systems engineering organizations, will be maintained through the application of configuration management disciplines to prevent changes detrimental to overall system reliability objectives. Problems arising from fabrication, assembly, and test which impact system reliability may be cause for reliability engineering to direct changes to engineering documentation (i.e., drawings, specifications, test procedures) to be made.

It will be the responsibility of the cognizant engineering manager for each subsystem to allocate the subsystem performance requirements to the units as part of his design process. All units will have specifications that define the design, acceptance, and qualification test requirements. These specifications will be approved and released by the cognizant engineering activity prior to initiation of fabrication.

7.3 Reliability Analyses

The following reliability activities will be conducted during the HIMSS design, development, and production phases:

- 1) Specification and documentation review, including design practices
- 2) Reliability prediction, including conformance to application and stress/derating requirements
- 3) Failure modes, effects, and critically analyses, including identification of single point failures and radiation assessment
- 4) Maintainability analyses
- 5) Participation in design reviews
- 6) Failure reporting, analysis, and corrective action
- 7) Parts and materials authorization and control

The HIMSS program product assurance manager will be responsible for ensuring that these activities are accomplished in a timely manner through audits, progress reports, and review of the outputs. Assigned reliability engineers will be responsible for implementing these task assignments.

7.3.1 Failure Modes, Effects, and Criticality Analyses

Failure modes, effects, and critically analyses (FMECAs) will be conducted for the HIMSS instrument in conjunction with PDR and CDR. As an integral part of the early design phase, Hughes will develop analyses to determine possible modes of failure and their effects on the mission objective. This analysis will be performed at the unit functional level and proceed through the spacecraft level. The major objectives of this analysis will be to assure that no single electronic or electrical failure will adversely affect the spacecraft or instrument payload and that no single electronic or electrical failure will adversely affect the spacecraft or instrument payload and that no single electronic or electrical failure will remove power from any instrument.

Accomplishment of suitable FMECAs will be the responsibility of the program product assurance manager. However, such analyses will be conducted as a joint activity of responsible reliability, unit, and parts engineers. At the integration level, the analyses will be supported by Systems Engineering. Emphases will be on potential subsystem failure modes and their effects on other subsystems.

The FMECA document flow and coordination between reliability and engineering activities will be as shown in Figure 7-1. Results of the failure modes, effects, and criticality analyses will be presented at the CDR.

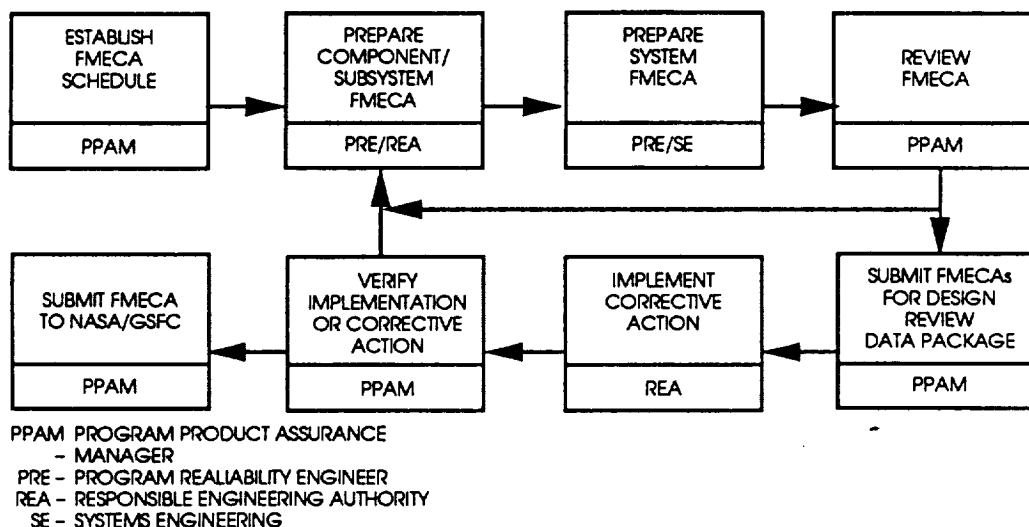


FIGURE 7-1. FAILURE MODES, EFFECTS, AND CRITICALITY ANALYSIS TASK FLOW

The primary objectives of these analyses will be to 1) identify critical failure areas, 2) enable the elimination of susceptibility to such failures or the attenuation of their effects on the instrument, and 3) minimize risk. To aid in apportioning efforts for corrective design action, the analysis will consider each potential failure in the light of its criticality. The identification and elimination of single point failures will be emphasized. Specifically, the failure modes, effects, and criticality analyses will

- 1) List all significant failure modes of each article of equipment and their effects on the instruments performance
- 2) List the causes of each potential failure
- 3) Identify all parameters contributing to these causes
- 4) Determine the degree of criticality of all significant failure modes
- 5) List the most critical failure modes in order of priority for study

The relative criticality of each failure mode will be ranked from the lowest (no effect upon performance) to the highest (resulting in failure of mission). Therefore, attention will be directed during evaluation of the design to eliminating or minimizing the effects of failure modes of the highest criticality. Space and Communications Group Product Assurance Instruction (PAI) 204 will be used as a guideline for preparing and documenting the functional FMECA.

FMECA data will be major item of consideration in design and management reviews and will facilitate other types of analysis design improvement, testing, and safe operations. It will typically be used to

- 1) Determine the need for redundancy, fail-safe design features, and/or further derating
- 2) Determine the need to select more reliable materials, parts, devices, and/or units
- 3) Identify single failure points
- 4) Support reliability models and predictions
- 5) Assure that the test program is responsible to known and suspected potential failure modes
- 6) Support establishment of requirements for personnel safety

- 7) Establish allowable use time or cycles as appropriate
- 8) Facilitate determination of quality inspection points
- 9) Establish data recording requirements and needed frequency of monitoring in testing, checkouts, and mission use as applicable

The corrective actions recommended as a result of the analyses will be included in the appropriate design reviews and in technical progress reports. Design changes that have been implemented as a result of FMECA recommendations or other conditions that affect the analyses will be reflected in appropriate FMECA updates. Revision of FMECA documentation after the CDR of any particular equipment will not be required except where design changes caused by failure modes or failure states make revision necessary. FMECA results will be summarized in the format shown in Figure 7-2. The FMECA will be used to identify single failure points in new and revised designs at unit and higher levels of assembly. Hughes will take the action necessary to eliminate single failure points insofar as practical. Each identified single point failure not eliminated through corrective design action will be identified on a single failure list and a rationale will be provided for acceptance of risk for the HIMSS missions. The rationale will include engineering assessment of the likelihood of occurrence and a discussion of measures that could be taken, if any, to eliminate the single point failure item. The single point failure list and rationale will be included in the PDR and CDR data package for the hardware elements in question and at the system level. The reliability engineer will prepare the single point failure list and accompanying rationales.

7.3.2 Reliability Assessment

The reliability estimates presented in the Hughes technical proposal for the HIMSS Instrument and its subsystems will be continually reassessed and updated as necessary throughout the program effort. Reliability analyses will employ parts count methods. The reliability of equipment for which documented reliability evaluations exist will not be reassessed. Existing documentation will be submitted as part of the reliability assessment package for design review (Figure 7-3).

Reliability analyses will assume the failure rates cited in Hughes Space and Communications Group Product Assurance Directive TBD, which are based upon MIL-HDBK-217D. Where a failure rate does not appear in MIL-HDBK-217D, Hughes will use failure rates based upon fair cumulative experience with equipment on Hughes in-orbit spacecraft.

The nominal environmental and operational stress conditions will be considered in established those actual failure rates to be used. In each prediction, consideration will be given to redundancy

and possible failure modes of components and assemblies. Derating analysis will be implemented at the part level and documented on schematic drawings used for reliability predictions. Tradeoff studies will be conducted considering redundancy, electrical stress of parts, and parts derating to assist design engineers in the optimization of unit designs.

Parts and components in an ON state will be considered to exhibit an active failure rate, whereas in an OFF state will be considered to exhibit a dormant failure rate.

7.3.3 Parts and Devices Stress Analyses

Parts application stress analysis of electronic, electrical, and electromechanical parts will be performed in accordance with Hughes Product Assurance Instruction (PAI) 209 prior to completion of the parts derating analysis. This analysis will evaluate the application of electrical, electronic, and electromechanical parts applied in circuits. The analysis will be performed at the most stressful electrical and environment levels. A typical stress analysis data sheet is shown in Figure 7-3. This analysis will be submitted to GSFC.

A parts derating analysis will be prepared utilizing results of the parts stress analysis. This derating analysis will be performed in accordance with MIL-STD-975, GSFC PPL-16, and Hughes PAI TBD.

Use of derating curves and adherence to stress derating policy by designers will be mandatory and will be reviewed by the program reliability engineer(s). The reliability engineer(s) will prepare a parts application derating analysis for each unit indicating actual stress and the relative derating of each part. This will encompass an analysis of each electrical part application to determine that the recommended derated levels of applied voltage, current, temperature, power dissipation, etc, have not been exceeded. The study will establish that under steady state and transient conditions the ratings of the parts are not exceeded. The application stress may be reduced by appropriate redesign or by choice of an alternate part when an overstress condition is discovered by these analyses. The parts and application derating analysis will be issued in report form for each unit and included in the data package for the Critical Design Review.

7.3.4 Worst Case Analysis

Hughes will conduct analyses that show how various indentured equipment levels (e.g., parts, circuits, modules) in the end item units are influenced by parametric variations, environmental effects, input and output limits, and variations, and transfer functions. The analysis will encompass worst case operating conditions, part derating, and part stresses due to application

effects. The analyses will include worst case operation for steady state and transient conditions occurring during turnon, turnoff, and performance state changes for the following parameters:

- 1) Maximum input signal variation
- 2) Maximum line voltage variations and line transients
- 3) Maximum part parameter variation
- 4) MAXimum performance demands
- 5) Maximum and minimum temperature
- 6) Fail safe provisions
- 7) Redundancy provisions

Results of the worst case circuit analyses and updates will be made available for review, upon request, by GSFC and summarized at CDR. The analyses will be performed by the responsible engineering activity (REA), and a continuous audit will be performed during the course of work by the program reliability engineer. Status of the analyses will be reported to the program product assurance manager.

7.3.5 Trend Analysis

Hughes will establish measurable parameters for the HIMSS instrument and its components to determine performance stability. These parameters shall be monitored for trends starting at the component level and continued through integration and test phases. Hughes will establish a recording and analysis system for the parameters that will track any changes from the first observed values even if the levels are within specified limits. A list of the parameters to be monitored shall be submitted in accordance with GSFC415-R-00004 Appendix C. Trend analysis data will be reviewed with operational personnel upon delivery of the hardware in order that they may continue to track trends throughout mission life.

7.4 Limited Life Items

Limited-life items will be identified on a list that will be submitted to GSFC. The list will include citation of each item's expected life and rationale for its selection. Limited-life items will be considered to include all hardware that is subject to degradation because of age, operating time, or cycles such that expected useful life is less than twice the required life when fabrication, test, storage, and mission operation are combined.

7.5 Reliability of Government-Furnish Property (GFP)

In the event Government furnished property is supplied by NASA/GSFC, NASA/GSFC will be responsible for supplying reliability data on those items. Hughes will request from NASA/GSFC the reliability data required to perform the spacecraft reliability analysis. In the event of failure, Hughes will notify NASA/GSFC and prepare a failure report in accordance with this plan.

8. QUALITY ASSURANCE PROGRAM

8.1 General Provision

The Hughes quality assurance program shall ensure that quality is built into the flight system hardware. The program quality assurance function shall establish and ensure the proper use of systems that facilitate the close teamwork between engineering, manufacturing, and quality assurance program. Established procedures shall provide for the prompt detection of deficient of marginal quality and provide for corrective action.

The program quality assurance quality assurance effort shall be administered in accordance with the Hughes SCG standard practices and organization. Each operations division has a line quality assurance function reporting directly to the division manager independent of the manufacturing line responsibility. This function is managed by a quality assurance manager who shall be responsible for implementation of the program quality assurance requirements for hardware within the division's product line. This responsibility includes communicating applicable quality assurance requirements to suppliers and subcontractors.

These quality assurance managers ensure conformance of items to the product description through appropriate systems and procedures for performance of inspections and audits. Quality assurance personnel shall perform appropriate inspections to verify that hardware and its documentation meet the workmanship and quality provisions of this plan from initial procurement through delivery of flight hardware. Each quality assurance organization shall be required to review, assess, and report the status of the quality program at scheduled program product assurance reviews.

An independent line of reporting between each operations division quality assurance manager and the Product Assurance Directorate, is enforced through the approval authority of the Directorate for all quality management appointments and quality practices. The program product assurance manager, in the functional reporting relationship he maintains to both the Directorate and the program office, issues appropriate requirements of this plan to each performing product line organization and conducts follow-up audits to ensure compliance.

Product assurance program management jointly with operations division quality representative will coordinate and clarify flow down of contract requirements into the engineering, procurement and manufacturing functions, early in the contract design phase. These activities include the issuance of necessary directives, instructions, procedures, and specifications to properly implement program requirements internally and to suppliers and major subcontracts.

8.2 Support of Design Reviews

Hughes Quality Assurance personnel will participate in design reviews to ensure consideration of quality requirements and inspection type characteristics.

8.3 Document Change Control

Engineering has established controls for the release of the changes to engineering documents and established in accordance with Hughes Engineering Procedures. Released engineering is distributed to document control centers where it is readily available to manufacturing, test, and inspection personnel.

The Quality Assurance system will document the as-built configuration of an item. Quality Assurance, in conjunction with Configuration Management, will ensure that:

- 1) Controlled drawings and manufacturing planning documents are used for inspection of hardware.
- 2) Controlled drawings are used for manufacturing purposes.
- 3) Manufacturing planning instructions contain drawing configuration status.
- 4) Changes are incorporated into the affected articles or materials at the authorized part.
- 5) Documents are revised in accordance with engineering changes and effectivities.
- 6) Items of equipment are marked in accordance with engineering requirements.
- 7) Items procured from subcontractors and vendors comply with the applicable configuration documentation.
- 8) Obsolete documents are removed from the operating areas.

The SCG Manufacturing Quality Control Practice in effect at the time of contract award will be used to enforce the requirements of this plan. Applicable procedures will be identified as program quality requirements and issued to the supporting quality assurance organizations by the Program Product Assurance Manager. Subsequent changes to the applicable procedures will be subject to change control and approved for implementation on the HIMSS program by the Product Assurance Manager. In the event of conflict between this plan and the subsequent detailed Quality Assurance Procedures, the Product Assurance Manager will require that supplemental instructions be issued to enforce requirements commensurate with this program plan.

8.4 Identification and Traceability

8.4.1 General Provisions

Engineering Procedures defining engineering practices for establishing part and serial numbers and their control will be utilized. These numbers will be used to identify the hardware and its related engineering procurement, fabrication, inspection, and test documents/records. Engineering, Manufacturing, and Quality Assurance will maintain a system capable of tracing each part to its purchase document or fabrication record and to its physical location for the flight articles.

8.4.2 Identification Methods

Parts, materials, and assemblies will be identified with a unique part number for control of individual items or lots of items or material. One or more of the following methods will be used, as applicable:

- 1) Date Codes when age control is necessary
- 2) Lot numbers or work order numbers when items are produced or processed in homogeneous groups
- 3) Serial numbers when individual control or data are required
- 4) Other identification such as tags, labels, paint dots, or containers as approved by Quality Assurance

A Master Index of instrument equipment will list subsystem, control items and components required for the HIMSS program by part number and quantity. This Index will be updated as changes occur to the hardware configuration.

8.5 Procurement Provisions

General procurement procedures are described in paragraph 1.8 of this plan. The following sub-paragraph provides a more detailed description of Hughes SCG procurement controls.

Hughes assumes responsibility for the adequacy and quality of materials, articles, and services procured for this program. These responsibilities include the following:

- 1) Selection of qualified sources
- 2) Transmittal of the design, reliability, and quality requirements to the supplier
- 3) Source/receiving inspection of procured items

- 4) Feedback information and corrective action system
- 5) Providing technical assistance and training to suppliers, when necessary, to improve quality levels
- 6) Providing supplier surveillance as required

Quality Assurance will screen and approve purchase requests prior to issuance to assure compliance with program requirements. Program quality requirements will be imposed upon suppliers by means of Hughes Quality (Q) attachments to procurement documents. A list of Q attachments and a description of their contents is shown in Table 8-1. The minimum quality levels to be applied to the HIMSS program will be as follows:

- 1) Protoflight and flight mechanical hardware other than major mechanical subassemblies will have a quality level of Q-4I and an inspection code requiring 100 percent verification of critical parameters to drawing requirements.
- 2) Major mechanical subassemblies and electromechanical parts for protoflight and flight hardware will have, as a minimum a quality level of Q-45 and an inspection code designated specific written instructions for receiving inspections and tests.
- 3) Protoflight and flight electronic parts will have a quality level and inspection code assigned that assures conformance to the requirements of HIMSS Program Parts/Devices Plan. Suppliers from which parts are directly procured, will meet the minimum requirement of Q-4I. Purchase order attachments will define supplier traceability requirement per Q-3. The part traceability system assigns a unique identifying number to each manufacturers lot and allows the parts after installation to be traced back to the screening or rescreening lot test data.
- 4) Potting compounds, epoxies, and adhesives, used on protoflight and flight hardware, will have a requirement for the supplier to indicate the data of manufacture and an inspection code requiring shelf life label.

Product Assurance will establish the requirements for Q attachments from Table 8-1 and define these in the Program Quality Requirements document. Q-5, for instance, will be imposed when positive imposition of chemical/physical analysis of materials and processes is determined to be imperative. Also Q-1 (Hughes source inspection/surveillance) will be imposed on procured items when the inspection cannot be performed at Hughes and on direct shipments.

Table 8.1. Quality Attachments for Procurement Documents

<u>Quality (Q) Attachments</u>	<u>Requirements</u>
Q-1 SAQ-1	Provides source inspection and SAQ-1 surveillance at supplier's facility
SBQ-1 SEQ-1	
Q-2	Requires first item produced be submitted to first article verification for compliance to applicable drawings and specifications
	Q-3 Traceability
Q-4C	Sellers's quality system
Q-4I	Seller's inspection system requirements (MIL-I-45208 equivalent)
Q-4Q	Seller's quality system (MIL-Q-9858 equivalent)
Q-4S	Seller's quality system (NHB 5300.4(1C) equivalent)
Q-5	Chemical and physical analysis of raw materials
Q-6	Certificate of shelf life and storage control
Q-8	Inspection and/or test data requirements
Q-11	Review of nonconforming supplies
Q-12	Government Source Quality Assurance
Q-13-I	Inspection system documentation
Q-13-Q	Quality Plan submittal

8.5.1 Product Changes

Latest applicable revision of drawings, engineering change orders, specifications, inspection/test instructions, reliability and quality requirements, and special instruction and/or test equipment, if required.

Suppliers having design cognizance obtain Hughes program office approval of any design or process change made after their product has passed qualification test.

8.5.2 Purchased Raw Materials

Notification will be made to the supplier to furnish a physical and/or chemical report of analyses and/or tests conducted to assure conformance to the specification, and when Q-5 is applicable, for procurement of nonproprietary raw material.

8.5.3 Raw Materials Used in Purchased Products

Notification to the supplier will be made by Hughes that he is responsible for maintaining records of the test conducted on his raw materials showing their acceptability, and that these records must be made available to Hughes upon request.

8.5.4 Age Control and Limited-Life Products

Age control and limited-life items will be controlled in accordance with paragraph 6.2.7 and 7.4 of this plan, and will be flowed down to Hughes' suppliers. Manufacture date or the date when useful life will be expended for items having definite characteristics of quality degradation or drift with age and/or use will be required.

8.5.5 Inspection and Test Records

Hughes will impose the following requirements on supplies for inspection and test records:

- 1) Inspection and test characteristics are contained in the technical documents for the article or material being procured.
- 2) Inspection/test records, required to verify compliance with purchase order requirements, must be identified and accompany the delivered hardware.

8.5.6 Government Source Inspection

When the government elects to perform inspection at a supplier's plant in accordance with paragraph 8.7, the following statement shall be included in the procurement document:

"All work on this order is subject to inspection and test by the government at any time and place. The government quality representative who has been delegated NASA quality assurance functions on this procurement shall be notified immediately upon receipt of this order. The government representative shall also be

notified 48 hours in advance of the time that articles or materials are ready for inspection or test."

8.5.7 Procurements Not Requiring Government Source Inspection (GSI)

Any procurement not requiring (GSI) on the HIMSS program will have the following statement on the purchase order:

"The government has the right to inspect any or all of the work included in this order at the supplier's plant."

8.5.8 Weld Filler Metal

Weld rods, weld wire and such procurements shall meet the requirement of MSFC-STD-655.

8.5.9 Hughes Quality Assurance Activities at Source

Hughes will utilize source inspection if any of the following conditions exist as determined by the product assurance manager or his designee:

- 1) If articles are at a level of assembly that precludes inspection at Hughes
- 2) If requirements not apparent during end item inspection/test (example: precap visual inspection), in-process controls must be monitored and verified to assure compliance.
- 3) If verification tests at Hughes are destructive in nature
- 4) If special test equipment or environment required is available only at the supplier's facility.
- 5) If past performance or quality history has been marginal
- 6) If tests at the supplier's facility are considered by Hughes as acceptance or qualification
- 7) If articles or materials are designated for direct shipment from supplier to the customer

Hughes Source Inspection/Surveillance will perform the following tasks as applicable to the item being procured:

- 1) Review the applicable purchase order, supporting documents, and technical documents for specified requirements
- 2) Monitor and verify or obtain objective evidence that articles being purchased meet the requirements of the

procurement documents

- 3) Obtain objective evidence that equipment used for acceptance or qualification tests has been calibrated and controlled
- 4) Review the supplier's manufacturing, inspection, and test records for compliance with requirements specified in the technical and associated documents referred in the purchase order

Surveillance activities will be sufficient to assure the desired product quality as defined by the purchase order and its supporting documents. Product complexity, criticality, state of the art, and supplier history will be prime considerations in determining the degree of the surveillance activity.

The supplier's quality system will be audited periodically to assure compliance with procedures. This includes monitoring of processes and manufacturing operations to assure compliance to contractual requirements and the supplier's procedures; examination of the supplier inspection and test operations to verify that the product conforms to visual, mechanical, and functional specifications; and verification of supplier's measuring and test equipment as within valid calibration periods.

Discrepancies or conditions that affect the product will be brought to the attention of the supplier for resolution.

8.5.10 Nonconforming Articles or Materials Resubmission

Resubmission of rejected parts or materials by a supplier will be identified as being submitted either on the articles or on the shipping documents. The supplier will be requested to make such references a part of the Hughes rejection document. Only the Material Review Board may authorize shipment from a supplier to Hughes or nonconforming material for Hughes evaluation.

8.6 Review and Approval of Procurement Documents

Review and approval of procurement documents are described in paragraph 1.8 and 8.1 of this plan.

8.7 Procurement Review by the Government

Hughes will forward procurement documents to the Government representative for review so that he can ensure compliance with controlling documentation and determine the need for Government source inspection (GSI). GSI will not replace Hughes source inspection.

Government representatives may audit the Hughes source

inspection system. If deficiencies exist, they will be reported to the Product Assurance Manager for corrective action. Should deficiencies continue to exist, the HIMSS Program Manager will be notified for corrective action. The need for delegation of Government source inspection will be determined by the procuring NASA installation or its designated Government quality representative and will be performed without impeding the work in progress or the movement of hardware to the next level of assembly or test, and will not include mandatory inspection points. Additionally, Government source inspection may be performed at supplier and vendor facilities.

8.8 Hughes Source Inspection

Hughes' source inspection and surveillance activities are defined in paragraph 8.5.9 of this plan.

8.9 Hughes Receiving Inspection

Parts and materials shall be inspected upon receipt or at the supplier's to ensure compliance with the requirements of technical documents and purchase orders. The amount of inspection or testing performed upon receipt shall be determined by the type of product, its end use, the amount of source inspection performed by Hughes, and the supplier's history. Emphasis shall be placed on verifying the conformance to specification of those characteristics whose nonconformance may not be detectable during subsequent inspections and testing. Results of inspections and/or tests shall be recorded on quality history records. Engineering designated sensitive items shall be identified in the program quality document and processed in accordance with quality instructions.

The receiving inspection system will ensure the following:

- 1) Quality data and/or test reports when required by the procurement document and reviewed to assure that the incoming items conform to the acceptance criteria defined in the engineering documents. These documents will be retained with the incoming inspection quality history records.
- 2) Incoming items and/or their accompanying documentation bear evidence of supplier/Hughes inspection. The Quality Assurance supplier record will be used to record results of Hughes source inspections performed.
- 3) Visual and mechanical inspections are performed on incoming parts and materials for compliance with applicable drawings, specifications, Hughes processes or catalogs, and the purchase order. The degree of electrical tests performed will be based on the generic part and part type, source inspection performed, and whether test data has been recorded and/or verified by source inspection. Electronic and electromechanical parts

listed in the Program Authorized Parts List will be subject to the inspection and test level requirements designated by receiving inspection codes on the purchase order. Sampling plans, when used in these inspections, are established by the SCG Quality Assurance Manual and have been submitted to NASA/GSFC as part of the product control data requirements.

- 4) Items and material ordered and received for the program are identified on receipt. Identification will also include the appropriate end item use, program designator, and inspection status.

Traceability will be required on all items and materials listed in the Program Authorized Parts and Materials List unless specifically exempted from the traceability requirement by notations within the list.

- 5) Receiving Inspection and Test has the necessary inspection and test equipment, drawings, specifications, catalogs, Hughes process specifications, etc., available to perform its operations upon receipt of the item. When supplier unique inspection or test inspection or test equipment is required, Hughes may verify the item's conformance at the supplier's facility.
- 6) Items having shelf life characteristics are inspected to ensure that the manufacturer's date is indicated and to affix a shelf life label. The Hughes SCG Shelf Life Manual will be used as a reference on all limited shelf life material.
- 7) When engineering documents require test specimens to be supplied with purchase items, these specimens receive the specified chemical and/or physical test upon receipt.
- 8) Raw materials are periodically chemically and physically analyzed on a sampling basis and when specified in engineering requirements
- 9) Quality status is maintained during the receiving operations, in addition to physical separation and identification of all items. Separation, as a minimum, will consist of the following:
 - a) Materials or articles awaiting inspection or test results
 - b) Conforming materials or articles
 - c) Suspended materials or articles
- 10) Articles and materials and their records indicate acceptance when released from Receiving Inspection and Test. All items released from Receiving Inspection and Test will be identified

with an inspection status tag or label. If the item is nonconforming, it will be routed to the Suspended Materials Control area with its quality history record which contains a description of the nonconformance for disposition in compliance with section 8.13.

- 11) In the case that parts are electrostatic discharge sensitive as noted in the part specification and/or the APL, an identifying label will be affixed to the part or its package.

8.10 Fabrication Control

Articles and materials shall be controlled at all times to ensure that inspection status is maintained and not compromised. Established controls shall include adequate handling and protection of items during all operations. Quality records maintained for in-process materials and articles shall identify the item and indicate its inspection, fabrication, and configuration status. The completed articles shall be identified in accordance with engineering requirements. A final inspection and review of documentation shall be performed to ensure that all required operations and inspections have been satisfactorily completed.

Fabrication, assembly, and rework operations shall be performed in accordance with planning documentation based on engineering technical requirements. Planning shall be prepared by the responsible engineering/manufacturing activities. Assembly planning documentation shall be screened to ensure that the inspection prescribed therein are adequate to ensure product compliance with engineering requirements. Screening shall be performed by quality assurance personnel or by certified planners/responsible engineers. Prescreened master planning documentation may be used.

Approval of planning documentation by quality assurance or other certified personnel shall be indicated by the application of an appropriate stamp or signature. Quality assurance personnel shall conduct scheduled audits of the fabrication and assembly areas and planning documents to ensure that operations are performed in accordance with established practices.

Fabrication and assembly operation will be performed in accordance with planning prepared by the responsible manufacturing activities from engineering documents. Planning documents will be submitted to Quality Assurance for review, before use, to determine if the instructions contained therein are adequate to provide maximum assurance of product compliance.

Prior to approving the planning documents, Quality Assurance engineering will assure that the planning includes the following:

- 1) Nomenclature, identification, and configuration status
- 2) Appropriate inspection and test operations (by source code, operation number, and reference to procedure, as applicable)
- 3) Proper call out of required tools, jigs, fixtures, etc., to accomplish the operations (by reference to part number or nomenclature, as applicable)
- 4) Call out for appropriate samples, including cure times and environments (as applicable to bonding operations, adhesives, etc.)
- 5) Required technical documents and process procedures as referenced on technical documents
- 6) Special handling, environmental, cleanliness, and packaging requirements, as applicable
- 7) Quality history, configuration, and traceability records for use with the assembly
- 8) Reference to workmanship standards and Hughes processes, when applicable
- 9) Written instructions complying to engineering documentation provided

8.11 Contamination Control

The fabrication and testing facilities utilized for the HIMSS hardware will be controlled for environment and cleanliness as required. Requirements will be specified by engineering documents in conformance with the instrument's Contamination Control Plan, Section 9. These documents define the cleanliness, humidity, and temperature requirements for controlling the work areas and personnel involved in the fabrication, assembly, and test of the HIMSS hardware. These requirements will be specified on the planning documents either in detail or by reference to engineering documents/specifications. The responsible fabrication, assembly, and test departments will be required to implement environmental and cleanliness requirements. Quality Assurance will assure adherence to the cleanliness requirements by performing periodic audits and area surveys.

Conditions found not in compliance, as stated, will be brought to the attention of the individual responsible for the area for immediate corrective action. Protoflight and flight items that have

been exposed to conditions not in compliance with the cleanliness requirements, will be identified "suspect" and will require disposition through appropriate material review action.

8.12 Electrostatic Discharge Control

Hughes SCG standard procedures will be used in controlling electrostatic discharge, following the guidelines of DoD-HDBK-263 and DoD-STD-1686. General provisions are described in paragraph 5.1 of this plan.

8.13 Nonconforming Article and Material Control

The identity and inspection status of all nonconforming items shall be documented on the appropriate quality history record at the point of discovery. The purpose of material review action shall be to disposition nonconformances.

Material review action shall determine whether the departure is due to hardware or documentation discrepancies. All review and closure actions shall be documented in accordance with existing contractor quality assurance practices.

Material review actions shall be final, requiring no further action. Items dispositioned as acceptable shall be processed thereafter as conforming items. The material review members and allowable dispositions shall be those cited in Table 8.2.

Quality assurance shall maintain a list of quality and engineering representatives authorized to perform material review actions. This list shall be available in all program areas that support material review actions. Members may call upon other personnel, such as reliability, stress, and thermal personnel, to act in an advisory capacity.

Preliminary Review

An initial review is conducted upon the discovery of a nonconformance. Workmanship errors and minor out of tolerance situations which can be reworked to specification conditions are dispositioned by authorized personnel through this preliminary review process. Preliminary review nonconformances are processed by the quality assurance inspector, quality assurance engineer, or cognizant quality assurance supervisor. Engineering and/or manufacturing input may be solicited for this action. During preliminary review, it shall be determined whether 1) a nonconforming item can be made to conform by rework or standard repair, if such has been previously authorized by the MRB, or

FUNCTION	MEMBERS	DISPOSITION
Preliminary Review	Quality Assurance	Rework/complete to drawing or specification requirements (i.e., resolder, replace, rewire) Low cost scrap Authorize standard repair Submit to engineering review or Material Review Board
Engineering Disposition	Engineering	Use as-is; minor nonconformances Rework/complete to drawing or specification requirements (i.e., resolder, replace, rewire) Scrap; unfit for use or uneconomically repairable Return to supplier Authorized rework to MRB- approved standard repair Submit to engineering review or Material Review Board Downgrade to nonflight
Engineering Review	Quality Assurance Engineering	Rework/complete to engineering drawing and specification requirements Return to supplier Downgrade to nonflight Rework to Material Review Board approved repair Instructions Use as-is; minor nonconformances Scrap; obviously unfit for use or uneconomically repairable Submit to Material Review Board
Material Review Board	Quality Assurance Engineering Program Product Assurance	Rework/complete to engineering drawing and specification requirements Return to supplier Repair (Includes initial approval of standard repair) Use as-is (Includes dropped or stressed hardware) Upgrade to flight status Downgrade to nonflight Scrap; hardware declared unfit to use Submit to customer for deviation or waiver approval

TABLE 8.2. FLIGHT HARDWARE MATERIAL REVIEW AUTHORITY

2) the item should be scrapped (low cost items only), or 3) the item must be submitted for higher level material review action.

Engineering Disposition

Any discrepancy, deficiency, or defect in fabricated piece parts below the assembly level (including microwave integrated circuit (MIC) carriers, substrates, and modules) may be processed by engineering disposition. This material review action is performed by engineering personnel responsible for the nonconforming item. The responsible engineer determines the disposition from both an engineering and a quality point of view, and may solicit the advice of other expert personnel. Nonconformance dispositions shall be documented on the appropriate records/traveler for the item(s). Quality assurance personnel shall conduct regular audits to ensure that appropriate dispositions are made.

Engineering Review

The engineering review level of material review action applies to all nonconformances not dispositioned by preliminary review, engineering disposition, or MRB action. It is performed jointly by the responsible quality assurance and engineering personnel who determine the acceptability of nonconforming items submitted for review. The responsible engineer documents and justifies disposition. The quality assurance representative shall signify concurrence with the disposition on the material review documentation.

Material Review Board

A formal MRB shall be established to review and disposition nonconforming material or hardware which can not be dispositioned under lower level material review authority. The MRB consists of representatives from program product assurance, quality assurance, engineering, and the customer, when required. The program product assurance manager or designee is chairman of the MRB. The quality assurance member of the MRB shall pursue all nonconforming material actions until disposition and closeout are complete. Material Review Board (MRB) action shall be required for the following:

- 1) Any nonconforming item referred to the MRB for final disposition (as any may be)
- 2) Any item found discrepant after its integration into the instrument when the disposition is use-as-is, repair, downgrade, or scrap
- 3) Initial review and approval of standard repair instruction (SRIs)

8.13.1.1 Nonconformance Definitions and Classifications

The following terms, definitions, and classifications shall apply:

- 1) Nonconforming Material - Any item, part, or product with one or more characteristics that depart from the requirements of the contract, specification, drawing, or other approved product description. Functional nonconformances must be processed through the failure reporting system.
- 2) Minor Nonconformance - A departure from the requirements specified in the approved product description that does not adversely affect contractual performance. Material nonconformance are processed through material review action.
- 3) Major Nonconformance - A departure from contractual performance that cannot be eliminated by authorized material review actions or reduced to a minor nonconformance by repair. Major nonconformances are processed by submitting a request for deviation/waiver to the customer for approval.

8.13.1.2 Corrective Action

Quality assurance personnel shall ensure that prompt action is taken to resolve nonconformances. Nonconformance documentation shall include cause and corrective action when it is beneficial to the program. Defect data from manufacturing records compiled into a data base shall be used to determine quality trends and the need for corrective action. Cause and recommended corrective actions shall be investigated by corrective action boards (CABs). Nonconformance data shall be reviewed for trends, corrective action assignments shall be made, and follow-up actions shall be taken. Management shall be kept informed of progress and completion of corrective action assignments through regularly published reports. Corrective action is taken in accordance with Hughes policy as defined in the quality assurance instructions.

Action taken to correct minor nonconformances shall not be required unless such action is beneficial to the program. It shall not normally be taken if:

- 1) The operation is monitored and discrepancies do not exceed the established limits
- 2) A discrepant item/operation has been discontinued or modified because of a design change.
- 3) Items are no longer being manufactured

- 4) An assignable cause cannot be determined

8.13.1.3 Subcontractor Material Review

Hughes SCG may delegate limited material review authority to selected subcontractors of complex articles. Subcontractors considered for material review authority shall be required to submit written plans for material review to Hughes for approval prior to implementation. Material review requirements for documentation, segregation, review, corrective action, and reporting need not be identical but shall be consistent with those prescribed by this plan.

8.13.2 Failure Reporting and Corrective Action

Hughes will establish a formal, controlled failure reporting, analysis, and corrective action system, responsive to the program requirements, through the use of program directives. The failure reporting system will be utilized for all hardware problems occurring at the first application of power (or the first test usage of mechanical items) at the lowest level of assembly above the part level for protoflight or flight configuration hardware. This system will be designed to maximize product reliability and quality through affective analysis and feedback of failure data during the test program. Failure analysis will be performed on failures occurring in subassembly, component, subsystem, and system levels protoflight and acceptance tests as determined by the REA, program reliability engineer, or product assurance manager.

The purpose of the failure reporting system will be to assure that 1) failures are correctly documented and analyzed; 2) failures are reviewed in the light of the current design, manufacturing, and test processes; 3) proper corrective actions are taken with accurate and timely closeout; and 4) failure information is disseminated to responsible personnel. This approach generates a true historical log of each failure and minimizes recurrence of each failure through changes to the procurement, design, manufacturing, or test methods.

8.13.2.1 Failure Reports

The failure reporting system is the primary source of information relating to functional defects and out of specification performance of hardware or software. The Hughes Space and Communications Group Failure Reporting, Analysis, and Corrective Action Procedure in PAI TBD will be used as a planning guide for preparation of a program instruction to implement those requirements. Hughes Failure Report Form 11873, and the Continuation Sheet Form 11873A, shown in Figures 8-1 and 8-2 will be used.

SPACE AND COMMUNICATIONS GROUP

FAILURE REPORT

F 40899

HUGHES

HUGHES AIRCRAFT COMPANY
SPACE AND COMMUNICATIONS GROUP
EL SEGUNDO, CALIFORNIA

SEE REVERSE SIDE OF HARD COPY FOR INSTRUCTIONS

ORIGINATOR	1. PROGRAM NAME AND NUMBER		2. GLA		3. MODEL		4. TIME OBSERVED		5. DATE OBSERVED YR MO DA	
	6. HDW UNDER TEST WHEN FAILURE WAS OBSERVED		<input type="checkbox"/> SPACECRAFT <input type="checkbox"/> SYSTEM		<input type="checkbox"/> SUBSYSTEM <input type="checkbox"/> UNIT		<input type="checkbox"/> ASSEMBLY <input type="checkbox"/> SUBASSEMBLY		<input type="checkbox"/> MODULE <input type="checkbox"/> MICAM <input type="checkbox"/> CARD <input type="checkbox"/> PART	
	EQUIPMENT IDENTIFICATION:		NAME		PART NUMBER		S/N		MANUFACTURER	
	7. SUBSYSTEM									
	8. UNIT									
	9. <input type="checkbox"/> ASSEMBLY <input type="checkbox"/> SUBASSEMBLY									
	10. <input type="checkbox"/> MODULE <input type="checkbox"/> MICAM <input type="checkbox"/> CARD									
	11. OTHER									
	12. TEST WHEN FAILURE WAS OBSERVED		<input type="checkbox"/> DEVELOPMENT <input type="checkbox"/> IN-PROCESS		<input type="checkbox"/> QUALIFICATION <input type="checkbox"/> ACCEPTANCE		<input type="checkbox"/> INTEGRATION <input type="checkbox"/> SYSTEM		<input type="checkbox"/> LAUNCH OPERATIONS <input type="checkbox"/> SPECIAL TEST	
	13. ENVIRONMENT WHEN FAILURE WAS OBSERVED		<input type="checkbox"/> AMBIENT <input type="checkbox"/> EMC/RFI		<input type="checkbox"/> RADIATION <input type="checkbox"/> VIBRATION		<input type="checkbox"/> TEMP _____ ° CYCLE _____ MIN TYPE _____		<input type="checkbox"/> THERMAL VAC _____ HRS AT _____ ° <input type="checkbox"/> OTHER	
14. DESCRIBE FAILURE, INCLUDE "IS" AND "SHOULD BE" DATA										
ENGINEERING EVALUATION	15. TEST PROCEDURE		PARA		16. ORIGINATOR		ORG		DATE	
	18. VERIFICATION AND FAILURE ANALYSIS									
	19. FAILED ITEM NAME		FAILED ITEM PART NO.		S/N		MFR		HDW LEVEL	
	20. <input type="checkbox"/> FOLLOWING REWORK/RETEST REQUIRED <input type="checkbox"/> REWORK/RETEST NOT REQUIRED BECAUSE									
MANUFACTURING AND TEST	21. AUTHORIZATION				ORG		DATE		22. CONTINUATION <input type="checkbox"/> SHEET USED	
	23. REWORK/RETEST ACTION TAKEN								24. QA REWORK	
									25. QA RETEST	
									26. QA RETEST (OPTIONAL)	
	27. LIST ALL PARTS REMOVED		HAC HI-REL		MFG		MANUFACTURER		REMOVAL CAUSE	
	PART NUMBER		PART LOT NUMBER		DATE CODE				FAIL CLASS	
ENGINEERING/RELIABILITY	28. REWORK BY		ORG		DATE		29. RETESTED BY		ORG	
									DATE	
	30. CONTINUATION <input type="checkbox"/> SHEET USED									
	31. CAUSE									
	32. CORRECTIVE ACTION								43. FRB CLOSURE	
34. DOCUMENT IMPLEMENTING CORRECTIVE ACTION								35. REF FR NUMBER		
36. BASIC CAUSE OF VERIFIED FAILURE		<input type="checkbox"/> DESIGN <input type="checkbox"/> ENVIRONMENTAL <input type="checkbox"/> DEFECTIVE PARTS		<input type="checkbox"/> TEST EQUIPMENT <input type="checkbox"/> TEST PROCEDURE <input type="checkbox"/> TEST SET-UP		<input type="checkbox"/> MFG. PROCEDURE <input type="checkbox"/> ASSY/FAB ERROR <input type="checkbox"/> WORKMANSHIP		<input type="checkbox"/> WIRING ERROR <input type="checkbox"/> ROUGH HANDLING <input type="checkbox"/> WEAR-OUT		
37. FAILURE TYPE		<input type="checkbox"/> PRIMARY <input type="checkbox"/> INDUCED		<input type="checkbox"/> UNKNOWN <input type="checkbox"/> NO FAILURE		38. FAILURE CLASSIFICATION		<input type="checkbox"/> CRITICAL <input type="checkbox"/> MAJOR <input type="checkbox"/> MINOR <input type="checkbox"/> SAFETY		
39. RESPONSIBLE ENGINEER		ORG		DATE		40. SPACECRAFT SYSTEM ENGINEER		ORG		
								DATE		
41. RELIABILITY		ORG		DATE		42. CUSTOMER OR SUPPLIER		DATE		

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FIGURE 8-1. FAILURE REPORT

INSTRUCTIONS FOR ENTERING DATA ON SCG FAILURE REPORT

The Failure Report (FR) is the required form for recording Space and Communications Group anomaly information. Only record one failure per FR according to the format indicated below. Use an FR continuation sheet if additional space is needed to complete any entry.

BLOCK	ENTRY DESCRIPTION								
1.	Enter program name and/or Hughes product model designation (Example: HSXXXI).								
2.	Enter GLA (First digits of cost account number). Obtain GLA from paperwork accompanying failed item, usually item planning document.								
3.	Enter appropriate spacecraft or system identification (Example: F2, Y1, Qual).								
4.	Enter time failure was observed. Note AM or PM.								
5.	Enter year, month, and day that failure was observed.								
6.	Check box defining hardware under test when failure was observed. (Example: If power supply subassembly fails during communications subsystem test, check "subsystem").								
7, 8, 9 10, 11.	Enter name, part number (P/N), serial number (S/N), and manufacturer of item on which failure was observed, on line that defines its equipment level. Then enter names, identification numbers, serial numbers and manufacturers of all known succeeding higher and lower equipment levels.								
12.	Check box defining type of test being conducted when failure was observed. If other than those listed, print appropriate type of test or operation in blank space and check adjacent box.								
13.	Check box identifying actual environment item being subjected to when failure was observed. Check more than one box if combination of listed environments is applicable. If other than those listed, print appropriate in blank space and check adjacent box. (NOTE: if failure was found during functional test before or after actual application of environment, do not check particular environment; if found before, check "ambient"; if found after, check both "ambient" and particular environment).								
14.	Enter information describing failure (Examples: inputs, outputs, tolerances, symptoms, or observed abnormal conditions).								
15.	Enter test procedures and paragraph number(s) being followed when failure was observed.								
16.	<u>Print</u> name and organization of originator, and enter date that FR was initiated.								
17.	Check if originator initiates continuation sheet. Enter this failure report number on continuation sheet.								
18.	Enter apparent cause of failure and steps taken to isolate failure mechanism. Determine if other parts or hardware have been overstressed.								
19.	Enter name, part number, S/N, MFR, and hardware level of verified failed item. This may be same as entry in Blocks 11, 10, 9, 8. Also enter additional information available at this time in Blocks 7 through 11. This is <u>not</u> a discrete part.								
20.	Check appropriate box. Describe either rework/retest requirements or reasons for not being required.								
21.	<u>Print</u> name and organization of person authorizing any rework/retest and enter date.								
22.	Check if Engineering initiates continuation sheet or makes entries on existing continuation sheet. Make sure this failure report number is entered on continuation sheet.								
23.	Describe failed item rework/retest action. Also, provide explanation if rework/retest action differs from Block 20 or if failed item as adjusted or modified.								
24, 25, 26.	QA stamps accepting rework and retest.								
27.	For each failed part, enter circuit symbols, part number, probable defect, lot numbers, and manufacturer and analysis number; obtain lot numbers from historical data accompanying failed item.								
28.	<u>Print</u> name and organization of person responsible for rework and enter date.								
29.	<u>Print</u> name and organization of person completing retest and enter date.								
30.	Check if rework/retest initiates continuation sheet or makes entries on existing continuation sheet. Make sure this failure report number is entered on continuation sheet.								
31.	Enter Engineering/Reliability conclusions as to cause of failure.								
32.	Discuss corrective action to prevent failure recurrence. If no corrective action taken, explain.								
33.	Check if Engineering/Reliability initiates continuation or makes entries on existing continuation sheet. Assure that this failure report number is entered on continuation sheet.								
34.	Enter type (Examples: ECR, ECN) and number of any documents used to implement corrective action.								
35.	Enter reference FR number.								
36.	Check box defining basic cause of verified failure. If other than those listed, print cause in blank space and check adjacent box. Insert assigned defect code.								
37.	Check box to indicate whether verified failed item was: <table border="0" style="margin-left: 40px;"> <tr> <td>Primary</td><td>Direct cause of failure</td></tr> <tr> <td>Induced</td><td>Derived from or dependent upon another failure</td></tr> <tr> <td>Unknown</td><td>Unknown whether primary or induced</td></tr> <tr> <td>No failure</td><td>Not a hardware failure</td></tr> </table>	Primary	Direct cause of failure	Induced	Derived from or dependent upon another failure	Unknown	Unknown whether primary or induced	No failure	Not a hardware failure
Primary	Direct cause of failure								
Induced	Derived from or dependent upon another failure								
Unknown	Unknown whether primary or induced								
No failure	Not a hardware failure								
38.	Check box denoting failure classification: <table border="0" style="margin-left: 40px;"> <tr> <td>Critical</td><td>Would normally cause mission abort or mission failure</td></tr> <tr> <td>Major</td><td>Would significantly degrade system performance</td></tr> <tr> <td>Minor</td><td>Would not significantly affect ability of system to function as designed</td></tr> <tr> <td>Safety</td><td>Also check "Safety" if a failure would result in damage to equipment or injury to personnel, actual or potential</td></tr> </table>	Critical	Would normally cause mission abort or mission failure	Major	Would significantly degrade system performance	Minor	Would not significantly affect ability of system to function as designed	Safety	Also check "Safety" if a failure would result in damage to equipment or injury to personnel, actual or potential
Critical	Would normally cause mission abort or mission failure								
Major	Would significantly degrade system performance								
Minor	Would not significantly affect ability of system to function as designed								
Safety	Also check "Safety" if a failure would result in damage to equipment or injury to personnel, actual or potential								
39, 40, 41, 42.	Enter signatures, organization numbers, and dates for persons closing out FR.								
43.	Affix Failure Review Board closeout stamp and/or enter FRB statement.								

FIGURE 8-1. (CONTINUED) FAILURE REPORT

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SPACE AND COMMUNICATIONS GROUP

**FAILURE REPORT
CONTINUATION SHEET**

FR SERIAL NO.

CONTINUATION SHEET LETTER*

*LABEL FIRST CONTINUATION SHEET USED 'A', SECOND 'B', AND SO ON

☐ IDENTIFY ENTRIES BY REFERENCING FR BLOCK NUMBER IN COLUMN, DATE EACH ENTRY.

ADDITIONAL FR
CONTINUATION
SHEET(S) USED

☐

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FIGURE 8.2 FAILURE REPORT CONTINUATION SHEET

The program product assurance manager will be responsible for assuring the functioning of the overall failure reporting system. Each operating organization will be required to support the system as follows:

- 1) Reporting of failures will begin with the first power application at the lowest level of assembly or with the first operation of a mechanical item; it will continue through formal acceptance by GSFC and the postlaunch operations.
- 2) Failure reports will be initiated by the unit, subsystem, or systems test engineer for any of the following failures that occur on protoflight, flight equipment and software under their cognizance;
 - a) All failures isolated to a part during and after the first functional test at the unit level or higher assembly level
 - b) All failures, including out of specification performance, which occur during or after start of acceptance test of a unit
 - c) Any unusual conditions occurring in test or handling at the unit level or higher assembly, including transients which are suspected to have an effect on the equipment as determined by the REA or product assurance manager
 - d) In the event the test engineer does not prepare a failure report for anomaly or failure within the 24 hour period, the quality test surveillance engineer will prepare the failure report and note the failure report number in the Quality Control History Report (QCHR).

Problems/failures will be reported for software or test equipment when a potential overstress to flight or protoflight equipment occurs.

Use of the failure reporting system on engineering model equipment will be at the discretion of the responsible engineer. In the event this equipment is to be used for qualification tests, failure reporting will be required.

- 3) The responsible engineer will be responsible for investigation, analysis, and corrective action taken to resolve each failure report written against the hardware for which he is responsible. In addition, the engineer will take full responsibility for completion of related

information on the failure report issued against his equipment. He will also provide support during failure reviews.

- 4) The program product assurance manager will be responsible for assuring that failure reports, including subcontractor failure reports and associate information, are reviewed for content and that failure report initiated efforts are carried to completion. In supporting failure investigations and analyses, the product assurance manager will give consideration to potential and/or probable relationship to previously reported problems/failures in this or related reporting systems. The program product assurance manager will also be responsible for ensuring that any questions regarding failure report closures are adequately covered and coordinated with the customer.
- 5) The system design and test engineering activity will originate failure reports during system integration and test and perform system level failure investigations. Failure reports will be initiated within 24 hours after verification of the failure. Systems Engineering will provide representation to the Failure Review Board and will support investigation and review of failures at the system level.
- 6) Quality Assurance shall ensure that adequate corrective action has been taken when the cause of failure is a manufacturing process or procedure.
- 7) SCG Product Assurance, SCG Component Engineering and Support Laboratory (CESL), or EDSG Technology Support Division (TSD) will provide failed part or material analysis support.

8.13.2.2 Failure Reporting System Operation and Control

The program product assurance organization will be responsible to the program manager for the failure reporting and closeout system. This organization will present the results of the failure reporting activity to NASA/GSFC.

The program product assurance organization, through the assigned reliability engineer, will be responsible for the following:

- 1) Prepare a program instruction implementing the failure reporting system along with those requirements unique to the program. These requirements shall include serialization of failure reports to assure accountability and closed loop corrective action.

- 2) Assure the documentation, maintenance, and coordination of failure reporting activities by subcontractors.¹
- 3) Maintain status cognizance of all failure reports through the Hughes approval cycle and report status to management and NASA/GSFC.*
- 4) Initiate procedures and action to immediately notify the designated NASA/GSFC representative of subsystem and system level failures.
- 5) Prepare and distribute failure reports and summaries to responsible organizations.
- 6) An oral notification of a failure will be made to the NASA/GSFC representative within 24 hours. Submit a copy of all failure reported generated to the designated NASA/GSFC representative within 72 hours of failure observation and/or reporting.
- 7) Monitor responsible organizations to determine adequacy of reporting and related actions.
- 8) Review documentation and data for trends and repetitive conditions
- 9) Following action by the Failure Review Board and closeout of reports by the program product assurance manager or his designee, review failure reporting system for timely action and provide copies of closed-out reports to the resident NASA/GSFC representative.
- 10) Prepare and distribute data package for Failure Review Board meetings, including agenda and copies of completed failure reports with appropriate supporting data.
- 11) Prepare and submit a cumulative summary status of all failure reports, failure analyses, and corrective action activities in the weekly status reports. Updated summaries shall also be provided at or before each monthly status review as input data for each design.

¹ A centralized failure reporting system will be utilized to control the quality, accuracy, and completeness of failure reports. A computer program will provide information on part, unit, subsystem or system by part number or serial number of an end item. Trend data can be furnished on demand and will be provided to the program manager and the program product assurance manager on a monthly basis or sooner if required. Trend analysis of failure reports will be kept current and will be available to GSFC.

Status summaries shall be dated and shall list each failure report as a separate line item. Summaries shall provide the following data:

- a) Identifying serial number of failure report and source (prime or subcontractor) of the report
- b) Test and site where problem/failure occurred
- c) Criticality category
- d) Occurrence date and closeout data (planned or actual)
- e) Identification of equipment affected, including serial or lot number, where appropriate, and drawing/part numbers, (with revision identification)
- f) Identification of end item, if known
- g) Brief description of problem
- h) Status of analysis and closeout actions, including projected dates for completion of these actions
- i) Identification of formal documentation changes supporting closeout (e.g., engineering order number or procedure modification number)

8.13.2.3 In-Process Failure Reporting

All nonconformance will be reported in the quality nonconformance documentation system. This system will complement the failure reporting function of the assurance activities, described in section 8, that report functional nonconformances and provide for documentation, review, and corrective action of minor nonconformances processed through the material review activity. Any rework resulting from failures will be subject to the inspection and retest procedures defines in Section 8.

Test failures occurring during subassembly and assembly will be documented on Failure Report Form 11873 and Continuation Sheet (Form D11873A). The in-process failures requiring part replacement due to part failure will also require failure investigation for disassembly or rework. Replacement of selects (reselection of capacitors and resistors) or the repositioning of tuning tabs are considered an integral in-process tuning technique and therefore no failure report required. Failure reports are not required on in-process manufacturing failures of parts, e.g., hybrids.

Any involved test personnel may initiate in-process failure reports. The REAs in all instances will be required to complete and close all in-process failure reports and provide the closed failure reports to the product assurance manager for reliability concurrence and submittal of in-process summaries to NASA. The in-process failure reports will not require review by the Failure Review Board.

8.13.2.4 Referral of Recurrent Nonconformances

Recurrent nonconformances will be referred to the failure reporting system and a failure report initiated by the program reliability engineer in the event of one of the following conditions:

- 1) A nonconformance cause that is not understood shall be referred on the second occurrence
- 2) A condition that is understood but required corrective/preventive action that cannot be obtained through means available to the system under which they are originally reported
- 3) Conditions which reflect process control system deficiencies after two occurrences, separated by seven days

Failure report initiated under the above conditions will be processed in accordance with procedures established for the HIMSS failure reporting system defined herein.

8.13.2.5 Subcontractor Failure Reporting

Selected subcontractors will be required to establish a Hughes approved failure reporting system in support of the Hughes system. Subcontractor failure report forms may be used to report failures and corrective action. When a subcontractor experiences failures during acceptance testing at the component level, he shall be required to write a failure report and send Hughes a TWX within 24 hours with all necessary information known about the failure. The failure analysis and closeout procedure for that failure report shall follow the same requirements as prescribed for Hughes and described herein. The Program Product Assurance Manager shall forward to the designated NASA/GSFC representative a copy of all such TWXs and failure reports upon receipt within a 24 hour period.

8.13.2.6 Failure Review Board

Hughes Failure Review Board (FRB) meetings will be held as required to review failure reports and closeout action. The program product assurance manager will act as chairman. Other members included are the cognizant component or subsystem engineer,

system engineer, reliability engineer, and quality engineer. The resident NASA/GSFC representative will be invited to attend each FRB meeting.

The chairman of the FRB will prepare and issue an agenda with items arranged in groups according to the equipment involved. The time and place of the meeting will be included in the agenda.

The Failure Review Board will review all reported failures to assure that:

- 1) Timeliness, accuracy, and completeness of failure reports is consistent with program requirements
- 2) Proper identification of the problem area is effected
- 3) Exact cause of failure is determined or that proper analysis has been conducted
- 4) Effective corrective action is being taken and, when necessary request additional corrective action. (This could include design change, manufacturing procedure improvement or change, and modification of operating instructions).
- 5) Final disposition of each failure for proper closeout is effected.

The FRB will assign, as necessary, action items regarding failure analysis and/or corrective action. Each action item will require a written reply to the FRB chairman within the agreed upon schedule.

8.14 Alert Information

Hughes is an active participant in the Government Industry Data Exchange Program (GIDEP). Alerts are reviewed by specialists in the SCG Components Engineering Support Laboratory (CESL), Materials and Processes Engineering personnel and in the Technology Support Division (TSD). Problems which may effect those parts listed in the Product Assurance Parts Selection Guide for Space Programs are coordinated with cognizant reliability, quality assurance and engineering personnel.

8.15 Inspection and Tests

Inspection and test functions will be conducted at those points during the fabrication, processing, assembly, and test operations that will provide maximum assurance of product compliance. Manufacturing operations will be performed as directed by the manufacturing planning. Inspections will be performed at

preplanned points to assure item compliance to engineering drawings/specifications, and for early detection of problem areas so that preventive measures can be taken before damage to flight hardware can occur.

8.15.1 Inspection and Test Planning

Manufacturing planning specifies the inspection and test functions to be performed during the fabrication, processing, assembly and test operations. The inspection and tests performed are based on the fabrication and process operations; the methods of material integration, assembly and checkouts; and the end requirements of the item involved. Manufacturing documentation will provide for recording inspection and test operations. All manufacturing planning will be coordinated and screened by quality assurance certified personnel prior to initiation of work.

8.15.2 Inspection and Test Procedures

Inspections and tests will be performed in accordance with engineering technical documents. These documents will be readily available and utilized by inspection and test personnel. In some areas, such as source or receiving inspection, an inspection and test instruction will be prepared to exemplify the engineering documents and other program documented requirements. These procedures will be coordinated between quality assurance engineering, inspection and test and the responsible engineering activity.

8.15.3 Inspection Activity

Inspection functions will be performed at points during fabrication, processing, and assembly that provide positive assurance of product compliance to requirements.

Inspection and test operations for electronic assemblies will consist of, but not limited to, the following:

- 1) In-process Inspection. Conducted on items that cannot, for reasons of accessibility or special process requirements, be inspected during pretest inspection.
- 2) Pretest Inspection. The complete inspection of the item and its process characteristics, as well as configuration verification to its engineering requirements.
- 3) Test. The testing of the functional characteristics of each item.
- 4) Post-test Inspection. An examination of each item for completeness and for possible damage that might have occurred during the previous operations, as well as the verification of configuration and completion of the

appropriate documentation.

Inspection points will be selected by quality assurance and included in the manufacturing planning. The inspection points will be prior to any operation which will obscure inspectable characteristics. Examples include pre- and post- test inspections, completed item inspections, witnessing operations that are not inspectable after completion, and other inspections determined to be necessary by quality assurance.

Crimped, soldered and welded electrical connections will be inspected to establish acceptability prior to being covered. Prior to installation of an item into the next higher level of assembly, the item will be inspected to establish conformance to engineering requirements proper identification, configuration, traceability data, verification of previous inspections and verification that the connectors are damage free and clean. Visual inspection will be accomplished with (6) times magnification unless otherwise specified in the technical documents.

Quality assurance will conduct required reinspection following all modifications, repairs, replacements, or rework performed on items previously inspected and accepted.

8.15.4 Quality Activities During Integration and Test

Quality assurance personnel shall perform in-process inspections during structural buildup, integration, unit installation and test. Inspection milestones shall include pre- and post-test inspections for major environmental exposure. Final acceptance inspection shall be performed following the test program to confirm compliance with requirements and specifications.

Control item acceptance tests shall be conducted in accordance with an approved test procedure to determine functional compliance. Subsystem level tests shall be performed in accordance with the approved test plan and its associated detailed test procedures. Test Procedures shall indicate the parameters to be tested, equipment to be used, environment in which the test is to be conducted, and acceptance criteria. Recorded test data and/or computer reduced data shall become part of the required documentation for record retention and shall constitute evidence of conformance to requirements.

The program product assurance manager shall specify a level of test coverage that ensures that significant elements of the test activities are monitored by assigned test surveillance personnel. Test area surveillance shall be imposed at all levels of acceptance testing as a minimum. The test area surveillance activity shall be accomplished by auditing test operations in progress to ensure that

- 1) Items are properly identified and handled.
- 2) Test procedures are available and being followed.
- 3) Test equipment is calibrated.
- 4) Test data and discrepancies are recorded.
- 5) Failure reports are initiated when required.
- 6) Test results are within the specified limits.

On an audit basis, this effort, in conjunction with other quality assurance activities, shall be of sufficient scope to ensure that delivered flight articles conform to requirements.

After completion of final tests and inspections, any replacement of parts, rework, or other modification of the hardware configuration shall necessitate a reinspection and retest to the extent determined necessary by the responsible engineer and cognizant quality assurance personnel.

8.16 Configuration Verification

Hughes quality assurance personnel shall verify as-built/as-designed configuration. The complete Configuration Management Plan is described in TBD and is submitted with this plan.

8.17 Metrology Controls

8.17.1 General provisions

Hughes maintains a documented metrology system for the control of measurement processes. The system provides the selection, approval, calibration, maintenance and control of inspection and test equipment as outlined in the Hughes Calibration and Measurement Standards system. This system is in accordance with MIL-STD-45662.

8.17.2 Acceptance

Measuring and test equipment will be inspected and tested to assure conformance to Hughes and/or manufacturer's specifications prior to its use for calibration or acceptance measurements on flight hardware. Records of these inspections and tests will be maintained by the responsible calibration control point.

8.17.3 Evaluation

Special inspection, measuring, and test equipment utilized to measure conformance will be evaluated by the cognizant engineering laboratories. The evaluation tests will be designed to verify that the special equipment measures the desired parameters properly, desired indications are provided, accuracy and tolerance of the

measurements system are correct and operating instructions are complete.

Commercial off the shelf equipment used in a manner consistent with its design need not be subject to evaluation test, providing sufficient information is available relative to accuracy, stability and repeatability.

The measuring and test equipment used by the Hughes Calibration Laboratory will be evaluated by the cognizant Calibration Laboratory engineers to assure adequacy of the equipment for the application.

8.17.4 Article or Material Measurement Process

An accuracy ratio (10) times the accuracy of the inspection and test equipment under calibration will be maintained wherever practical. As a minimum, a 4-to-1 accuracy ratio should be maintained when direct measurements are being performed. When the 4-to-1 accuracy ratio cannot be met, the combined error of the measuring instrument system and the observed error of the equipment or point under test must be less than the stated tolerance for the equipment or point under test. When 4-to-1 accuracy ratios cannot be maintained, approval is required from the product assurance manager.

8.17.5 Calibration Measurement Processes

An accuracy of 4-to-1 or greater will be maintained. When the 4-to-1 accuracy ratio cannot be met, the combined error of the measuring instrument system and the observed error of the equipment or point under test will be less than the stated tolerance for the equipment or point under test. When the accuracy ratio is less than 4-to-1, the on-site customer representative will be notified.

8.17.6 Calibration Controls

Primary standards are initially and periodically certified directly or through a precise comparison with the standards maintained by the National Bureau of Standards.

Secondary standards maintained by supporting organizations are initially and periodically certified directly or through a precise comparison with the standards maintained by the Hughes Primary Standards Laboratory.

All organizations or individuals responsible for, or who effect the handling or transportation of measuring and test equipment, will exercise proper care in the movement or storage of such equipment.

A standard system is employed by Hughes for indicating the certification/calibration status of measurement standards/measuring and test equipment. Unique labels or codes provide identification, and last and next calibration dates. These calibration indication

status labels or codes will be applied to items capable of being calibrated which are not required to be used to their fullest capabilities.

Inspection, measuring, and test equipment is periodically maintained and recalibrated. The intervals for recalibration depend on use, accuracy, type, required precision, and other conditions effecting measurement control. Basic calibration intervals are established for each model or type of equipment by the organization authorized to perform the calibration.

The basic calibration interval is used for initial and periodic calibration until a significant quantity of data have been accumulated for each model or type. Recalibration intervals are adjusted on the basis of analysis of detailed historical records. Intervals may be lengthened when results of previous calibration provide definite indication that such lengthening of intervals does not adequately affect accuracy of the system.

Records will be prepared and maintained showing the calibration status of each item of measuring and test equipment. These records will show, as a minimum, the date of last calibration, date of next calibration, calibration interval, calibration procedure use, and conditions of the equipment when received (i.e., in calibration, out of calibration, physical condition, and required services).

8.17.7 Environmental Requirements

Each calibration laboratory establishes environmental requirements to assure continued measurements of the required accuracy, giving due consideration to temperature, humidity, vibration, cleanliness, and other controllable factors affecting precision measurements. When applicable, compensating corrections will be applied to calibration results obtained in an environment departing from standard conditions.

8.17.8 Remedial and Preventative Action

A data feedback system between the users and the Calibration Laboratory will be employed to advise the using activity and responsible quality assurance organizations when test equipment are determined to be risk defective (marginal or inaccurate) at the time of periodic calibration. A Calibration Data Feedback form is forwarded to the activity that submitted subject measuring and test equipment with a copy to the responsible quality assurance organization. The responsible quality assurance organization will then determine if the inaccurate or marginal measuring and test equipment has effected quality of the operation and initiates appropriate corrective action as required.

Audits will be performed by the cognizant quality assurance section to verify that measuring and test equipment being used is currently calibrated and properly set up and maintained; also that

unauthorized equipment is not being used for formal tests. A regularly scheduled report will be published listing delinquent measuring and test equipment which have not been submitted for calibration in accordance with the established schedule. This report will be sent to the cognizant quality assurance section for action. Equipment not recalibrated before the recall date will be removed from service or recalibrated. Authorization for calibration exceptions may be obtained only with concurrence of the program product assurance manager.

8.18 Stamp Controls

8.18.1 Stamp Control System

Hughes quality assurance organizations maintain a system according to the Quality Assurance Manual, procedure 19-47-00 for the control of inspection and calibration stamps used within the company. These controls include the issuance, traceability records, and use of each type of stamp. Stamps will be used on all planning documentation, inspection instruction reports of suppliers, receiving inspection documentation, nonconforming documentation, and other appropriate documents. Each type of stamp will indicate whether the article inspected/tested is accepted, suspended, accepted after material review, calibrated, calibrated by whom, and will show final acceptance of the article. Stamping methods and marking materials will be accomplished by stamping the article or, due to impractical nature and physical limitations so as not to compromise the quality of the article, stamping will be done on supporting documentation, i.e., an Inspection Status Tag.

Inspection stamps are identified by a system which provides traceability via stamp control records to the individual responsible for its use. The issuance of stamps is limited to authorized quality assurance personnel. Verification of stamp possession and employee location will be performed periodically by each quality assurance organization.

8.18.2 Stamp Restriction

The shape, size and configuration of assigned Hughes stamps shall not reflect the designation of any customer, nor will they be altered in any manner to do so.

8.19 Sampling Plans

Hughes' sampling plans shall be used when inspections or tests are destructive or when inherent characteristics or noncritical applications indicate that a reduction in inspection or testing can be achieved. MIL-STD-105, Sampling Procedure and Tables for Inspection, shall be used as a guide to establish approved sampling plans.

The degree and quantity of required inspections and tests shall be determined by review and analysis of previous inspection and test results. Rejected lots and resubmitted lots may be reinspected using tightened sampling techniques.

8.20 Training and Certification

Early in the program, and on receipt of new engineering requirements, the dedicated program quality assurance engineer will investigate the new items, processes, test techniques, etc., being considered by engineering and will establish special training programs accordingly.

Training and instruction to improve the skills of key personnel will be accomplished by each quality assurance and manufacturing section. Training programs will be coordinated with the Personnel Training and Certification Department of the Products Operations Division. Training and retraining will be required when new processes or assembly techniques are introduced and when inspection and test results or internal audit reports indicate the possibility of deterioration in job performances.

Personnel training and certification program documentation will be made available to the customer upon request.

Hughes personnel responsible for controlling special processes will be certified. Certification will be required for personnel performing potting, soldering, electronic module welding, structural welding, encapsulation, radiography, ultrasonic testing, liquid dye penetrant inspection and magnetic particle inspection. The certification program will include necessary training, followed by a testing procedure. Personnel unable to meet the certification requirements will not be permitted to perform the operation involved and will be given additional training prior to retesting and certification. Records will be maintained of all certified individuals. Each person certified will be given a dated card or badge as evidence of that certification which will be carried while performing those tasks requiring that certification.

Results of inspections and quality audits will be used as indicators of the need for additional training and recertification prior to the normal certification period expiration.

Excessive discrepancies identified by inspection results will be subject to corrective action. When these discrepancies are traced to processes being out of control, the corrective action may require recertification of personnel, change in process or procedure, change in engineering, etc. In high volume areas such as wire harness fabrication, process areas, machine output, etc., control charts will be used to indicate when and where corrective action may be required.

Records will be maintained which indicate those persons certified, the specifications, and schedule for recertification. Normal recertification periods are (1) year, unless stated otherwise by a process specification.

8.21 Handling, Storage, Marking, Packaging and Shipping

8.21.1 Handling

Engineering drawings, procedures, specifications and program instructions will define the requirements for preservation, packaging, handling, storage and shipping of articles and materials in accordance with NHB 6000.1 and Section 7, Reliability, of this plan. These requirements will be incorporated in work authorizations, planning documents, operating procedures and engineering instructions, and are subject to review by quality assurance personnel.

8.21.2 Storage

Controlled storage facilities will be provided for all flight hardware, component parts, subsystems and minor control items.

No other hardware must be delivered to flight stores. Identification and inspection status of all items will be maintained. Where required, special maintenance and inspection instructions will be prepared to assure and protect the integrity of the articles stored.

8.21.3 Preservation

All articles subject to deterioration or corrosion through exposure during fabrication and interim storage will be cleaned and preserved in accordance with engineering requirements specified in technical documentation. Articles packaged for shipment under the terms of the contract will be preserved in accordance with applicable requirements.

8.21.4 Marking and Labeling

Marking and labeling for packaging, storage and shipment of articles and materials are performed in accordance with applicable engineering technical documentation and/or contractual requirements.

8.21.5 Packaging

Responsible engineering activities will determine if articles are subject to deterioration, corrosion, or damage in the package state and will indicate in the technical documentation the necessary precautions to be observed to prevent damage. When maintenance of specific internal or external environments is necessary, this will be included in the packaging instructions and will be provided on

the exterior of the package. Quality assurance organizations will audit/inspect the engineering requirements as applicable.

8.21.6 Shipping

All items shipped from Hughes will be subjected to shipping inspection. This inspection will ensure the following:

- 1) Articles have been subjected to and have satisfactorily passed applicable inspections and tests.
- 2) Articles are complete and fully assembled as required.
- 3) Articles have been preserved and packaged in accordance with applicable procedures, specifications, and/or engineering instructions.
- 4) Packaged articles have been identified and marked in accordance with applicable procedures, specifications, and/or engineering instructions.
- 5) All shipping documents and containers that contain flight units or parts thereof are marked "Items for Space Flight Use" with integrity seals placed on the container.
- 6) Articles shipped are accompanied by documentation required by contract.
- 7) Handling devices and transportation vehicles are suitable for articles involved.
- 8) Loading and transportation methods conform to the applicable requirements.
- 9) In the event an unscheduled product removal from a container is required, the extent of reinspecting and retest will be authorized by the customer representative.

8.21.7 Documentation Package

Articles shipped will include a complete documentation package. The package will contain all applicable documents required by contract suitably marked "Items for Space Flight Use." When contract requirements indicate that the data package is to be contained within the shipping container, the container will be marked to indicate the data package location.

8.22 Government Property Control

8.22.1 Contractor's Responsibility

Hughes will be responsible for controlling and accounting for all customer furnished equipment and associated documentation supplied in accordance with the provisions of the contract.

Upon receipt, customer furnished equipment will be inspected for in-transit damage and to verify that the article is complete and as specified in the shipping documents. The accompanying documentation will also be examined by quality assurance personnel to determine if the requirements of the supplied article have been met.

Under no circumstances will an article be unpacked or subjected to a receiving inspection environment until a review has been made of the environmental requirements of the particular article to ensure that the integrity of previously accomplished inspection and cleaning procedures is maintained.

Quality Control History Records supplied with the shipment and documentation originated during receiving inspection will be maintained.

Quality assurance personnel will initiate a log book upon receipt of the equipment. This log book will contain events in chronological order beginning with receiving inspection and tests and continuing through integration and final delivery activities. Responsibility for the continued maintenance of the log book lies with the activity having cognizance over the equipment. The log book will identify the property, continuous location of the property, date, types and results of Hughes inspections, tests and other significant events.

8.22.2 Unsuitable Government Property

All Government furnished property found to be damaged, malfunctioning, or otherwise unsuitable for its intended use will be identified as nonconforming material, segregated, and protected from further damage or deterioration. Hughes will promptly notify the customer of the discrepancy for their disposition.

8.23 Government Acceptance

Hughes quality assurance personnel shall ensure that deliverable end-items, including the acceptance data package, are in accordance with contract requirements and that the data package is submitted to the customer in accordance with GSFC 415-R-00004 Appendix C. A copy of the data package will accompany the end-item as part of the shipment.

9. CONTAMINATION CONTROL

9.1 General Provisions

The Contamination Control Plan is provided as a separate document and will be submitted along with this plan.

4.3 CONFIGURATION MANAGEMENT PLAN

HUGHES

Space and Communications Group

GOVERNMENT ELECTRONICS SYSTEMS DIVISION

HS256C-1045-0056

CONFIGURATION MANAGEMENT PLAN

**FOR THE
HIGH RESOLUTION MICROWAVE
SPECTROMETER SOUNDER
(HIMSS)
INSTRUMENT PROGRAM**

**AN INSTRUMENT FOR NASA'S
EARTH OBSERVING SYSTEM**

PRELIMINARY

OCTOBER 1990

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1. INTRODUCTION

Hughes Corporate configuration management (CM) procedures have proven effective for NASA, military, and commercial spacecraft programs. The Hughes Corporate configuration management policy document is signed by the Corporate Director for Product Effectiveness, and defines the following responsibilities and basic principles for implementation of configuration management:

- 1) Establishing configuration management functions and responsibilities.
- 2) Receiving and analyzing customer configuration management requirements
- 3) Establishing internal configuration management operating plans and procedures in accordance with customer requirements.
- 4) Preparing, releasing, and maintaining configuration identification (specifications, drawings, and standards).
- 5) Controlling and administering changes to released configuration identification and corresponding software/hardware.
- 6) Defining, specifying, and monitoring the implementation of subcontractor and vendor configuration management requirements and controls.
- 7) Establishing and implementing configuration status accounting procedures for reporting information needed to effectively manage the configuration of systems and/or equipment.
- 8) Applying configuration verification techniques to ensure correlation between configuration identification and software/hardware.
- 9) Conducting configuration audits as required by contract or Company policy.

To implement its Corporate policy, Hughes has a two-volume Drafting Room Manual and Engineering Procedures Manual (Hughes Policies and Procedures) that apply to the HIMSS program as specified in this plan.

The configuration Management Plan for the HIMSS program is based on an organizational structure, procedures, and methodology that are responsive to all NASA requirements. The plan provides a cost-effective, time-phased application of configuration management

tasks such as product structure, drawing release, specification management, change control, status accounting, configuration audit, change verification, and data management.

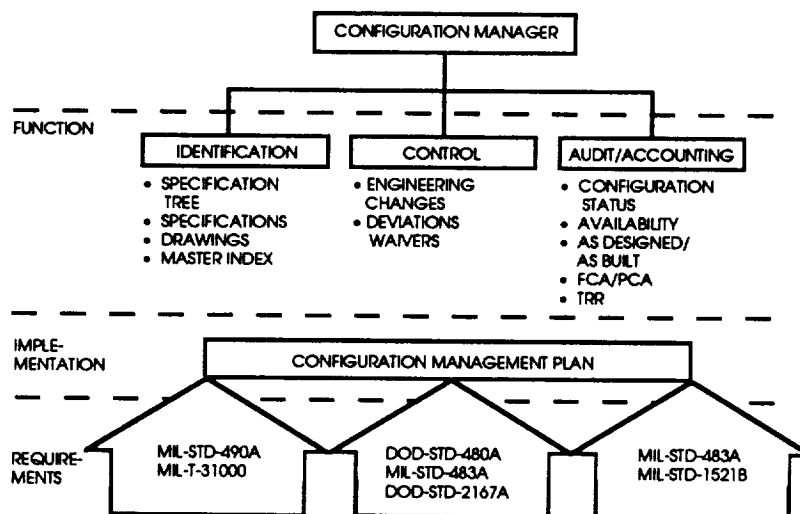
The plan defines a system with the following key elements:

- 1) Providing minimum response time for drawing and change releases, while maintaining configuration control.
- 2) Adopting a change classification and approval method to assure both: a) customer approval and Class I engineering changes that impact the contract, and b) cost-effective implementation of Class II engineering changes.
- 3) Ensuring customer access to all HIMSS documentation generated on the program.

The Configuration Management Plan described herein also provides the means for formally identifying and controlling all hardware and software engineering changes to the system as specified in NASA specifications.

1.1 Applicable Documents

The documents illustrated below are applicable to this plan:



CONFIGURATION MANAGEMENT ORGANIZATION - CM SYSTEMS PROVIDE COMPLETE VISIBILITY INTO DESIGN CONFIGURATION AND ARE FULLY COMPLIANT WITH MIL-STD's

1.2. ACRONYMS LIST

<u>Acronym</u>	<u>Definition</u>
1. APL	Authorized Parts List
2. CDR	Critical Design Review
3. CDRL	Contract Data Requirements List
4. CI	Configuration Item
5. CM	Configuration Management
6. CMO	Configuration Management Office
7. CRB	Change Review Board
8. DCC	Document Control Center
9. DM	Data Management
10. ECA	Engineering Change Analysis
11. ECAE	Engineering Change Analysis Evaluation
12. ECC	Engineering Change Center
13. ECP	Engineering Change Proposal
14. ECR	Engineering Change Request
15. EDL	Engineering Data Control
16. EDCP	Engineering Document Change Proposal
17. EDRS	Engineering Data Requirements System
18. EO/RN	Engineering Order/Revision Notice
19. FCA	Functional Configuration Audit
20. FRR	Flight Readiness Review
21. HAC	Hughes Aircraft Company
22. HIMSS	High Resolution Microwave Spectrometer Sounder
23. ICD	Interface Control Drawing
24. NSPAR	Nonstandard Part Approval Request
25. PCA	Physical Configuration Audit
26. PCDMO	Program Configuration/Data Management
27. PDR	Preliminary Design Review
28. PDTR	Pre-Delivery Turnover Delivery
29. PI	Program Instruction
30. PQR	Program Quality Requirements
31. PRR	Program Requirements Review
32. REA	Responsible Engineering Activity
33. SDRL	Subcontractor Data Requirement List
34. SOW	Statement of Work
35. SRR	System Requirements Review

2. CONFIGURATION/DATA MANAGEMENT ORGANIZATION

The Configuration and Data Management organization is organized under one manager and is established as separate and distinct from the Systems Engineering organization and the Responsible Engineering Activities (REA) headed by the task manager. (See Figure 2-1). The HIMSS Program Manager is responsible for the overview of all configuration management activities. The configuration Manager implements and maintains the configuration management system for the program for both hardware and software.

The Configuration Manager is tasked with establishing the practices and procedures that will be used to ensure compliance with all requirements and specifications of the contract and Statement of Work. Subject to final decision by the Program Manager in conjunction with the customer, the Configuration Manager has the following authority:

- 1) To direct the Responsible Engineering Activity and/or the Systems Engineering Manager to comply with this configuration management plan, the contractual documents, and/or any Company standard practices or procedures.
- 2) To direct any Responsible Engineering Activity to ensure or maintain configuration traceability and parts pedigree on all qualification and deliverable hardware/software.
- 3) To declare nondeliverable or nonqualified any hardware and/or software that does not comply with this plan.

2.1 Configuration Management Responsibility

The principal responsibility of the HIMSS Configuration Manager is to maintain the integrity of the system design. This function is fulfilled by the following activities:

- 1) Providing liaison between Hughes, NASA, and other program participants for configuration and data management-related activities.
- 2) Maintaining records of all NASA and Hughes Change Review Board (CRB) decisions and pending actions.
- 3) Coordinating preparation, approval, and release of all specifications, drawings, Interface Control Drawings (ICDs), software listings and media other configuration-controlled documents, SDRL documents, and selected in-house requirements, documents.
- 4) Assisting with Engineering Change Proposal (ECP) preparation and coordination.

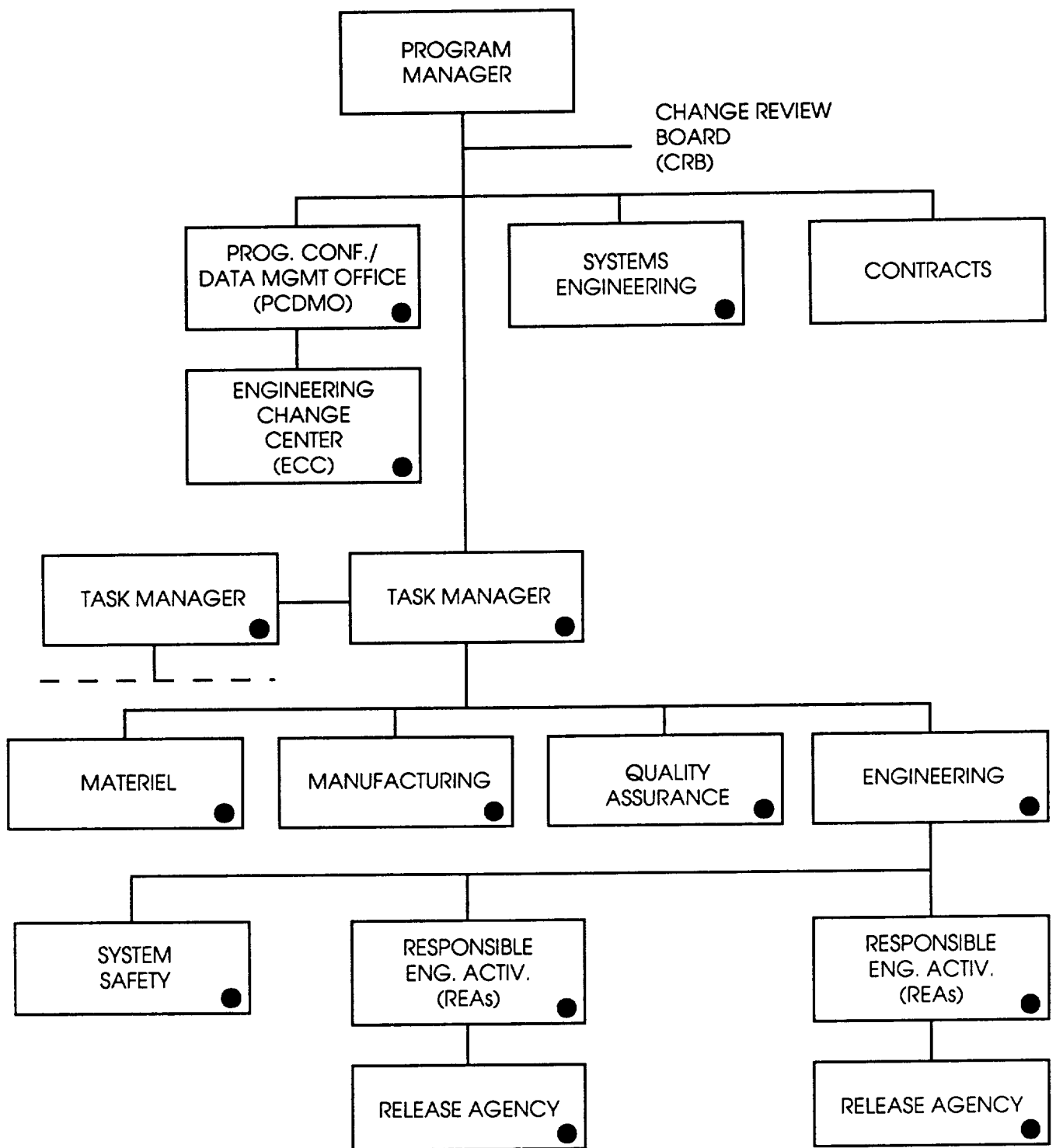


FIGURE 2-1. HIMSS PROGRAM MANAGEMENT ORGANIZATION

- 5) Participating in design reviews and providing administrative assistance.
- 6) Directing engineering release activities.
- 7) Controlling and administering all engineering and quality history data generated as a result of program effort.
- 8) Monitoring engineering data preparation, delivery, and status reporting.
- 9) Ensuring that subcontractor and vendor configuration requirements are established in procurement documents.
- 10) Supporting Quality Assurance in the control of as-built configuration, test data, and computer program documentation.
- 11) Coordinating changes to approved documents.
- 12) Supporting system test through completion, including control of all test data.
- 13) Performing all Configuration/Data Management related audits, configuration inspection, identification, PDR, CDR, PRR, PDTR, FAR.
- 14) Ensuring the integrity of the configuration.
- 15) Providing a certificate of flight worthiness pedigree for all flight hardware and computer software from lowest level to each final end item.
- 16) Providing verifiable trail of all changes so that any differences between qualification unit and flight units can be defined at time of delivery.
- 17) Developing and maintaining the Program data management system.

2.2 HUGHES ENGINEERING PROCEDURES AND PROGRAM INSTRUCTIONS

2.2.1 Engineering Procedures

Hughes will use group prepared Engineering procedures which specify how engineering and configuration/data management tasks or operations are to be accomplished. The instructions included are consistent with, and support the basic requirements set forth by the Company and the Government. They also provide a framework for conducting engineering and configuration/data Management disciplines on all SCG programs in accordance with current Government requirements.

2.2.2 Program Instructions

Hughes will use Program Manager approved program instructions to implement unique HIMSS requirements. The configuration manager will be given the responsibility for preparing and issuing these program documents. Program Quality Requirements (PQR) will be coordinated with the configuration management plan to ensure consistency and the application of program configuration management requirements that are directly monitored by Quality Assurance personnel. Program instructions are written to clarify unique requirements as appropriate and to insure inter-group compliance.

3. CONFIGURATION IDENTIFICATION

Configuration Identification is the technical documentation of an item as set forth in specifications, drawings, software media, and their referenced documents.

3.1 Baseline Identification

The program will use the following baselines;

- 1) Program/Project Requirements Baseline - Established as a result of an approved program specification.
- 2) Design Requirements Baseline - Established as a result of an approved Part I Detail Specification.
- 3) Product Configuration Baseline - Established as a result of an approved Part II End Item Detail Specification.

3.2 Configuration Verification

This task requires that the Configuration office verify that the manufacturing units are built to the configuration described in the released engineering documentation. This verification is performed for each control item and to its lowest serialized assembly.

During the manufacturing assembly process all as-built data from manufacturing and quality assurance for all modules, subassembly, assembly, and control item (unit) levels will be received, audited, and filed in the Configuration Management office. During system integration/test, the configuration manager assures that manufacturing maintains a current installation/removal log for use during the configuration verification process. All as-built data from Manufacturing and Quality will be reviewed and maintained by the Configuration Management Office.

The "as-designed" report generated from the EDRS computer data listings will be compared with "as-built" data.

The Hughes Authorized Parts List (APL) will provide a list of parts for HIMSS usage. All new parts will be submitted on Nonstandard Part Approval Request (NSPAR) forms required for HIMSS Hardware will be researched and tested to provide information required for concurrence. Status of all parts will be shown on the APL under the column labeled "NSPAR Status". It may be necessary for Hughes to use some parts at its own risk while waiting for customer concurrence.

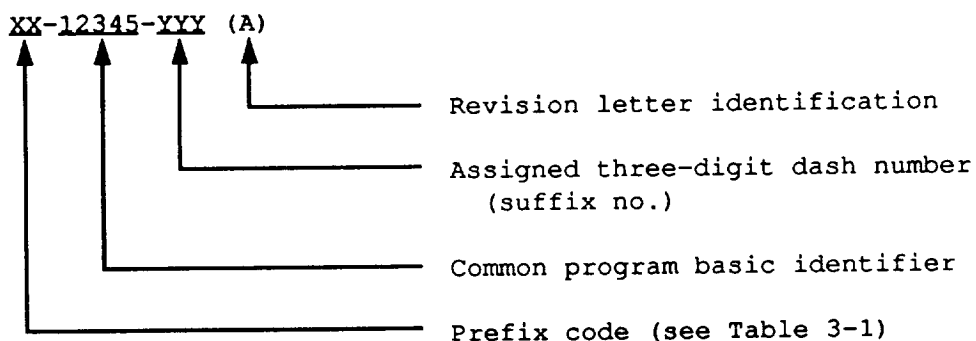
Discrepancies found on serialized assemblies will be documented and resolved through Quality Assurance, the applicable manufacturing

planner, and/or the Responsible Engineering Activity prior to the applicable Flight Readiness Review (FRR). Any rework subsequent to the FRR will require verification and closeout by the Configuration Management office.

3.3 Specifications

The HIMSS system and subsystem specifications will establish configuration identification to the system, subsystem, and component level. These specifications are written to eliminate duplication in preparation and maintenance of separate documents. For example, component design specifications are generally not prepared. Instead, component designers will take their requirements from subsystem specifications. The different types of specifications to be prepared by Hughes for the HIMSS program are listed and described in Table 3-1. Hughes Engineering Procedures will be used as a guide for the preparation of HIMSS specifications.

Unique specification numbers (12345) will be assigned as a basic identifier for the HIMSS specifications to be prepared by Hughes. This basic identifier, along with the prefix code and an assigned three-digit suffix number (dash number), provide complete identification of individual specifications. Revisions to specifications are identified by a letter suffix. The Configuration Manager assigns the suffix numbers for Hughes' specifications shown in Table 3-1. The composition of individual specification numbers is as follows:



3.3.1 Specification Tree

A specification Tree will be prepared by the Configuration Manager for systems and equipment to list and show the relationship of the program's specifications. Specifications are identified in the tree by number, title, subsystem and relationship to system specification revision.

Table 3-1. Summary of Specification Categories.

System/Subsystem	SS	Specifies system/subsystem performance requirement and provides basis for development of constituent items of subsystem.
Interface	IS	Specifies system, subsystem, or other spacecraft equipment subsystem.
Procurement	PS	Specifies performance, interface, and design requirements, and provides basis for procurement of specific equipment items; may include test requirements.
Detail Process	DP	Specifies engineering requirements, process sequences, quality assurance provisions, etc., for chemical, metallurgical, or other production test requirements.
Test	TS	Specifies system/subsystem or control item equipment performance requirements for test purposes.

3.3.2 Test Plans and Test Procedures

Test plans and test procedures for hardware/software are assigned numbers by Configuration Management. After the plans and procedures are approved, the document is formally released, and change control is maintained by Configuration Management.

3.3.3 System Test Plan Compliance Demonstration Matrix

Systems engineer prepares a compliance test matrix that lists all of the system performance parameters and correlates them with

unit/system test.

3.4 Engineering Drawings

Engineering drawings include all assembly drawings, schematics, wire lists, interface control drawings, configuration lists, and any other drawings required to build, inspect, test, and accept hardware/software for spacecraft usage. Configuration lists to be prepared include a master index (Sample - Attachment 1); hardware scroll (which defines total program requirements including spares) (Sample - Attachment 2); and a specification tree that will be delivered to NASA. The master index will identify and relate all HIMSS equipment down to the control item/unit level for configuration control purposes. The hardware scroll is an extension of the master index and will list all flight and development hardware quantities, including spares.

A three-digit suffix number (dash number) will be provided for drawing type identification. The dash number will be assigned in accordance with Table 3-2. Drawing numbers for equipment below the unit/control item level will be assigned by the subsystem engineering activity and will be defined in appropriate configuration lists. Revisions of drawings are always identified by revision letter (e.g., Revision A, B, C).

The Corporate Hughes Drafting Room Manual, which is applicable to this program, has been prepared to ensure that engineering drawings are prepared and maintained in compliance with the requirements of MIL-D-1000, Drawings, Engineering and Associated Lists, Level, 2, for flight hardware.

Table 3-2. Drawings Number Type Identifier Suffixes

<u>Suffix</u>	<u>Drawing Type</u>	<u>Suffix</u>	<u>Drawing Type</u>
-1XX	Top Assembly	-6XX	Unassigned
-2XX	Schematic Diagram	-7XX	Spacecraft installation
-3XX	Wire Diagram	-8XX	Block diagram
	List/or ICL		
-4XX	Interface Control	-9XX	Unassigned
-5XX	Installation Control		

3.4.1 Indentured Drawing List

An Indentured Drawing List (IDL) is prepared for each control item to identify and show the relationship, during design and development, of the engineering drawings that delineate the control item. The drawings are listed by number and title in indentured form.

The IDL is prepared by the Responsible Engineering Activity (REA), starting with identification of the engineering drawing for the control item and continuing through the design and development phase. The IDL provides the REA and others with visibility of the drawing structure for a control item.

3.4.2 Subcontractor/Vendor Equipment

Major items of equipment procured for the HIMSS program will be identified by Hughes specification control drawings and procurement specifications. Items procurable from limited sources will be identified by Hughes' source control drawings. Government or industry standard documents and equipment item applicable to the program will retain their Government or industry standard drawing/part numbers. Section 6 describes HIMSS subcontract/vendor control requirements.

3.4.3 Serialization

A serial number, when associated with an item's serialization base, uniquely identifies that item. The serialization base may be a control item identifier or a part number. Serial numbers shall be assigned by System Engineering/REAs. These numbers shall be consistent and in ascending order, e.g., 001-999 or 1-99 or 101-999. Serial numbers may be assigned to items below control item level for use in collection of test data or to provide traceability.

Starting serial numbers are specified on engineering drawings. Numbers are composed solely of numerals and are consecutive, beginning with Number 1 for newly designed hardware. Serialization of hardware used on previous programs will continue upward from the last unit/assembly manufactured. The serialization marking requirements for an item are entered on the drawing that specifies the identification marking requirements for the item.

Manufacturing maintains records that show serial number application during manufacture.

3.5 Software Media

Software media includes tapes, disks and diskettes. Media identification and marking will be done according to Hughes Engineering Procedures Section 12.

3.6 Drawing/Specification Release

Flight equipment drawings and specifications will be formally released in accordance with Hughes standard procedures as specified in Hughes Engineering Procedures. Existing drawings from other Hughes programs which are currently in a formal release status can be utilized if they are screened for compatibility with HIMSS requirements and then incorporated directly into the drawing

structure. Any existing drawing that does not meet these requirements will be revised and reissued as a unique HIMSS drawing. All new/revised drawings/specifications will be processed through the Configuration Management office. After formal release, copies will be available to meet customer requirements.

3.7 Configuration Identification List

Configuration Management obtains configuration identification data directly from released engineering documentation (e.g., specifications, drawings) and uses these data to prepare HIMSS current drawing status list. This is a standard computer listing designed to include current revision letters and outstanding change identification data for released specifications and drawings. Change effectivity and control item usage are also included in the list.

4. CONFIGURATION CONTROL

Program configuration control will consist of classification and processing of proposed HIMSS engineering changes, including requests for deviation and waivers. This process consists of the uniform and systematic origination, analysis and preparation, review and approval, authorization, and release of engineering changes. Engineering changes affecting the fabrication, testing, rework/repair, and handling of flight equipment will be classified as Class I or Class II with the Class I change having the more extensive program impact.

4.1 Change Classification

Change classification is the primary basis of configuration control and is the initial configuration control function. All engineering changes are classified as Class I or Class II, with the following change criteria as a guide. Class I change control is in effect at contract award and requires formal Change Review Board (CRB) review and approval.

4.1.1 Change I Engineering Changes

A Class I change is a change that affects program contractual requirements (program schedule, cost, system performance or customer controlled interfaces), or meets any/all of the requirements defined in MM 8040.12A, paragraph 4.2.1 "Class I Engineering Change", and requires customer approval prior to implementation into the engineering document, hardware or software.

4.1.2 Class II Engineering Changes

Any engineering change to which the criteria for Class I does not apply is by definition a Class II engineering change.

4.1.2.1 A class II engineering change requires an Engineering Change Analysis (ECA) form and it does one or more of the following:

- 1) Affects contractual product configuration identification.
- 2) Requires a new part number(s).
- 3) Adds or exchanges items other than Government or industry standard attaching hardware.
- 4) Affects two or more (REAs) control items. (Except record changes).
- 5) Requires revision of authorized internal funding.
- 6) It does not fall within the Class I definition of MM 8040.12A, paragraph 4.2.1.

4.1.2.2 Class II engineering changes other than those described in paragraph 4.1.2.1 may be completely documented and processed on an Engineering Order - Revision Notice (EO-RN) form (Short Form Engineering Order - Revision Form).

4.2 Change Initiation Forms

A Hughes Engineering Change Analysis (ECA) form will be used for processing all Class I and II changes as described in paragraph 4.1.2.1 (see Figure 4-1 and 4-2). The ECA form (see Figure 4-3) and necessary supporting engineering documentation are also used for submittal of Class I Engineering Change Proposals to NASA. Class II engineering changes described in paragraph 4.1.2.2 are processed using short form Engineering Order - Revision Notice (see Figure 4-4).

4.3 Review/Approval Requirements

Approval requirements are different for the two classes of engineering changes. The most comprehensive approval requirements are imposed on the Class I change. (Ref. Figure 4.1 and 4.2).

4.4 Change Review Board

The HIMSS CRB will review and issue a notice of disposition (approval or rejection) for all proposed Class I or Class II engineering changes prior to implementation. The Chairman of the CRB is the HIMSS Performance Assurance Manager, or his designee; the CRB secretary is the Configuration Manager who will participate in the CRB process. Board members include representatives from Program Management, Product Assurance, Systems Engineering, Safety, Manufacturing and other activities as required by the proposed change. HIMSS CCB membership is illustrated in Figure 4-6.

4.5 Deviations and Waivers

Deviations and waivers (RDW) provide a means of departing from requirements specified in HIMSS engineering documents without altering the documents. Deviations must be authorized prior to hardware manufacture. Waivers are requested for nonconformances found during or after manufacture. The RDW will be submitted to Configuration Management for processing as described in the Engineering Procedures Section 5, which also describe the method of classification. Copies of all deviations and waivers will be provided to the NASA representative.

Minor waivers are processed as a function of Material Review Board action. Major deviations and waivers will require NASA approval prior to release, when contractual requirements are affected.

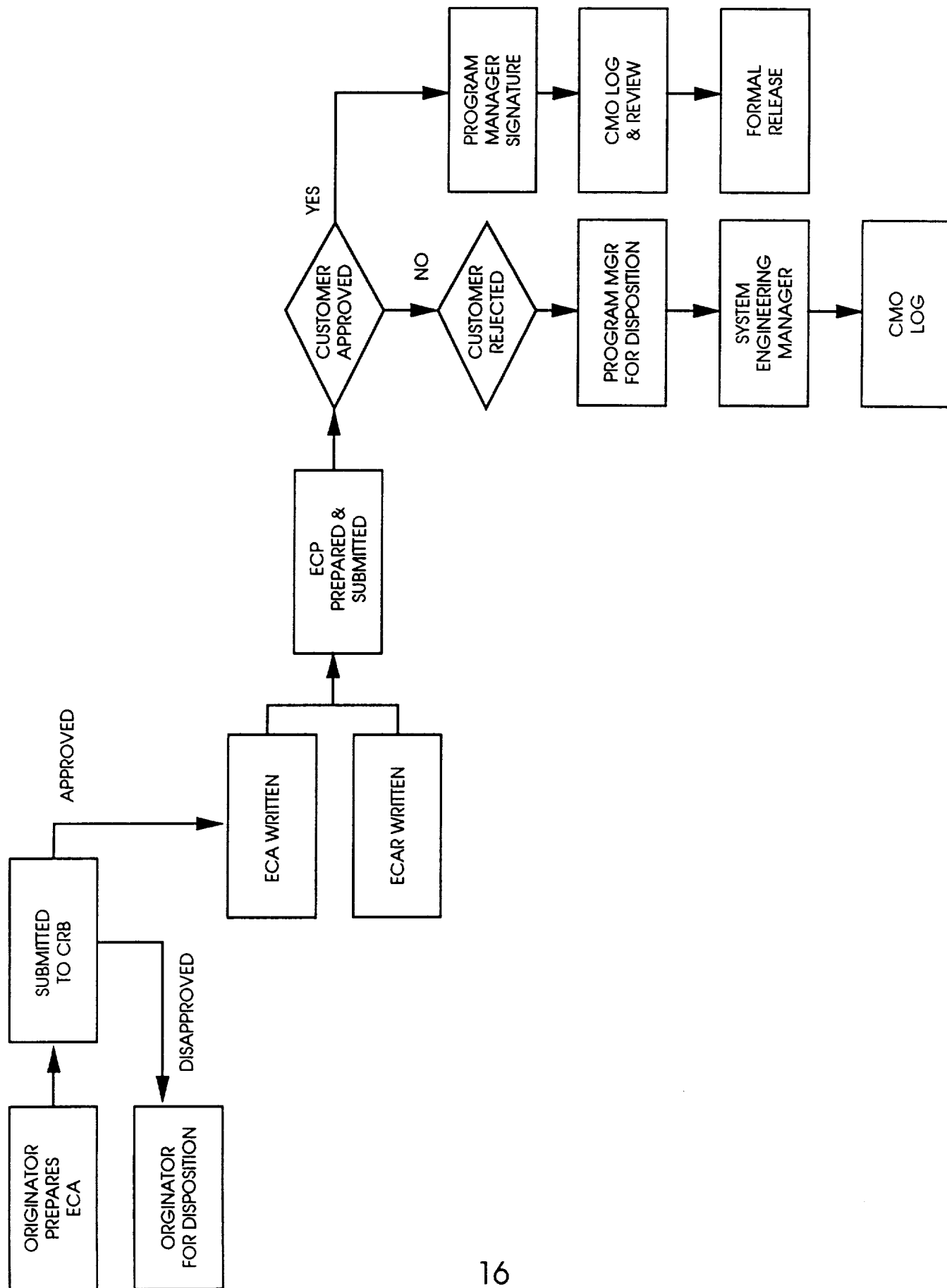


FIGURE 4-1. CLASS I CHANGE PROCESS FLOW DIAGRAM

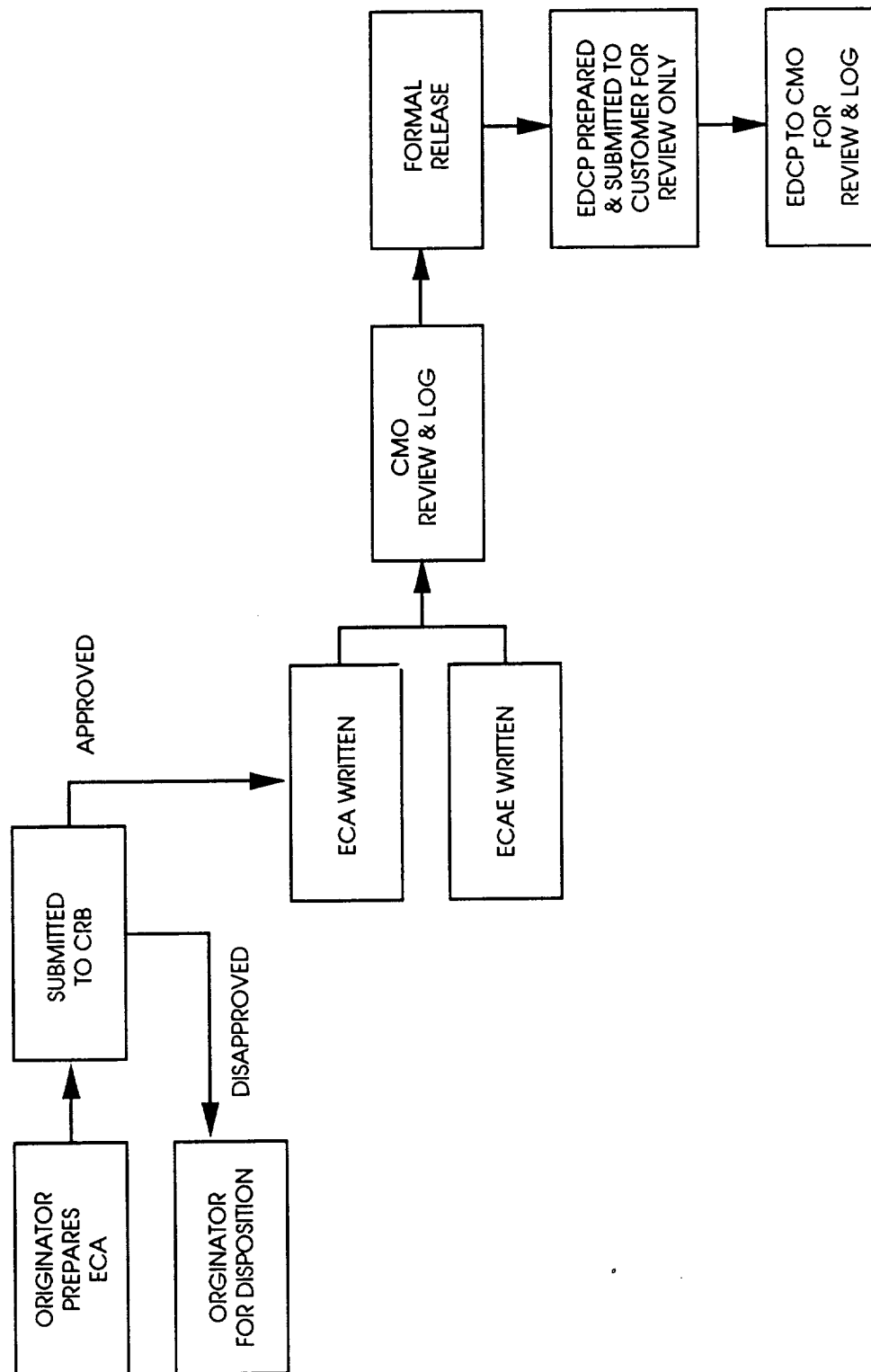


FIGURE 4-2. CLASS II CHANGE PROCESS FLOW DIAGRAM

SPACE AND COMMUNICATIONS GROUP ENGINEERING CHANGE ANALYSIS SHEET 1 OF ____				ECA NO. _____		REV _____		<div style="border: 2px solid black; padding: 5px; display: inline-block;"> HUGHES </div> CAGEC 82577	
				<input type="checkbox"/> COMPLETE/FINAL		<input type="checkbox"/> PARTIAL			
PROGRAM			CONTROL ITEM NAME AND NO.				ECR NO.		
RELATED ECA NO.(S)		CLASS <input type="checkbox"/> I <input type="checkbox"/> II		DATE PREPARED		REQ COMPL DATE		CONTRACT NO.	
BASE LINE AFFECTED <input type="checkbox"/> FUNCTIONAL <input type="checkbox"/> ALLOCATED <input type="checkbox"/> DEVELOPMENT <input type="checkbox"/> PRODUCT							BASELINE SOURCE <input type="checkbox"/> HUGHES <input type="checkbox"/> CUSTOMER		
SPECIFICATIONS AND ENGINEERING DRAWINGS AFFECTED									
SPECIFICATION OR DRAWING NUMBER	NEW	REV LTR/NO.	EO/SCN NO.	DELETED	SPECIFICATION OR DRAWING NUMBER	NEW	REV LTR/NO.	EO/SCN NO.	DELETED
TITLE OF CHANGE							RELATED FACTORS ON SHEET 2 ARE AFFECTED <input type="checkbox"/>		
DESCRIPTION OF CHANGE									
JUSTIFICATION FOR CHANGE									
EXTENT OF TESTING						RECM EFFECTIVITY			
						RECM DISPOSITION OF ITEMS CODE A <input type="checkbox"/> INCORP CHG B <input type="checkbox"/> USE C <input type="checkbox"/> NOT APPLICABLE			
APPROVALS FOR EVALUATION									
REA	ORG CODE	DATE			ORG CODE	DATE	REQUIRED ECAE <input type="checkbox"/> MAEC <input type="checkbox"/>		
DEPT/TASK MGR									
DCC/ECC									
CHANGE REVIEW BOARD APPROVALS									
<input type="checkbox"/> APPROVED <input type="checkbox"/> REJECTED			ORG CODE	DATE			ORG CODE	DATE	
					CHAIRMAN				
AUTHORIZATION FOR RELEASE									
ECP NO.	EFFECTIVITY				CUSTOMER		DATE		DISTR/PROCESS EDC/DCC CODE DATE
CONTRACT AUTH. NO.	DISPOSITION OF ITEMS				PCMO		DATE		

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FIGURE 4-3. ENGINEERING CHANGE ANALYSIS (ECA)

ENGINEERING ORDER – REVISION NOTICE						DWG NUMBER AND REV LETTER		CAGEC NO. 82577	
DWG TITLE						<input type="checkbox"/> EO NO. _____ SH _____ OF _____			
PROGRAM NAME				GLA		<input type="checkbox"/> REV NOTICE SH _____ OF _____			
CONTROL ITEM NAME			SYS/EQPT			AUTHORITY			
CONTROL ITEM PART NUMBER	DISP CODE	CHANGE EFF	CONTROL ITEM PART NUMBER	DISP CODE	CHANGE EFF	CONTROL ITEM PART NUMBER	DISP CODE	CHANGE EFF	
ZONE	DESCRIPTION								
JUSTIFICATION				CIRCLE REASON FOR CHANGE		A DRAWING ERROR		D SPECIFICATION ERROR	
DISPOSITION OF ITEMS AND CODE LETTERS				B DESIGN ERROR ELECTRICAL		E REQUIREMENTS CHANGE		G PROCUREMENT CHANGE	
INCORPORATE CHANGE A				USE B		NOT APPLICABLE C		H MANUFACTURING CHANGE	
						C DESIGN ERROR MECHANICAL		I DEVELOPMENTAL DESIGN CHANGE	
PREPARED BY			ORG CODE		DATE				
CHECKED BY			ORG CODE		DATE				
RESPONSIBLE ENGINEERING ACTIVITY			ORG CODE		DATE		PCMO		DATE
			ORG CODE		DATE		RELEASED BY		DATE

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FIGURE 4-4. ENGINEERING ORDER – REVISION NOTICE (EO-RN)

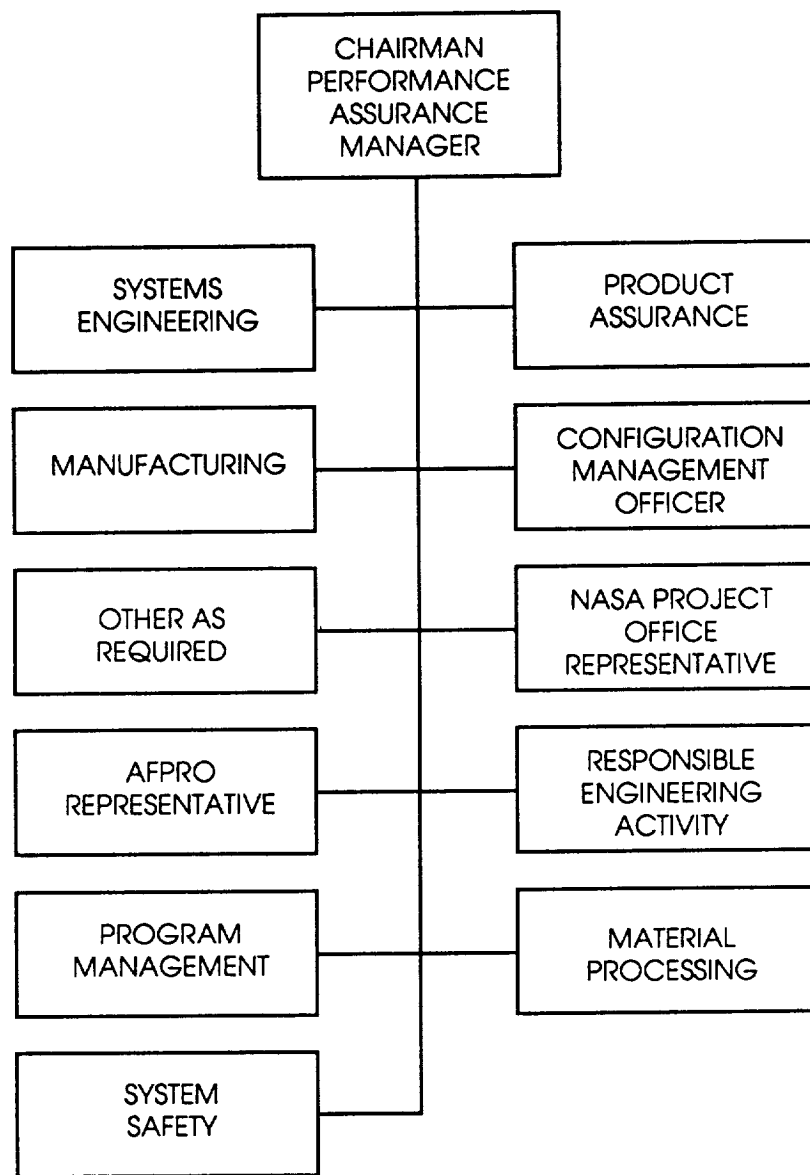


FIGURE 4-6. HIMSS CHANGE REVIEW BOARD MEMBERS

4.6 Procedures

The Hughes flow process of an engineering change is initiated by preparation and signoff by the Subsystem Manager of a proposed engineering change. Procedures for processing and handling the change after signoff by the Subsystem Manager vary for the different classifications of change. A process flow diagram for Class I changes is shown in Figure 4-1. A process flow diagram for Class II changes is shown in Figure 4-2.

Class I ECP processing requires a cooperative effort by Hughes and NASA to avoid adverse schedule and cost impacts. Early informal coordination will be used to assure rapid ECP preparation and approval by Hughes and NASA. Configuration Management helps to prepare and process ECPs for preliminary and formal submittal to NASA.

NASA response times for Class I ECPs are as follows:

<u>Priorities</u>	<u>Response Time</u>
Emergency change requests	24 hours
Urgent change requests	15 calendar days
Routine change requests	45 calendar days

To expedite processing, emergency and urgent ECPs can be processed and approved by FAX and/or TWX.

5. CONFIGURATION STATUS ACCOUNTING

The configuration status accounting function provides a listing of the documentation that identifies the configuration at any point in time, the number of engineering changes approved, and the status of implementation of the approved engineering changes.

5.1 Configuration Reports

Drawings and specifications data will be available in the computer data base. Product structure and as-design type reports can be extracted as required. A typical report is the Master Index. The index lists all control items, quality spares, etc., and is prepared in accordance with Hughes Engineering Procedures Section II.

5.2 Status of Changes

Configuration Management will maintain the status of all changes from initiation of a request for change through the processing activity to disposition. An engineering change log is maintained from receipt of the change request to engineering release or cancellation of the change request. Also all change status will be input to the EDRS database. For Class I and Class II changes an ECA number is assigned, and tracking will then be conducted by that ECA number until closure of the change by engineering release or cancellation.

5.3 Configuration Audit Process

Configuration audits are conducted 1) to provide support to the PRR, PDR, CDR and CI in addition to but not limited to FRR, FCA/PCA. (Reference MM 8040.12A Exhibit X).

The PRR is a formal review, to verify the suitability of the conceptual configuration of the EI/major elements to meet mission objectives, to establish and to update its baseline.

The PDR is also a formal review to verify the basic design approach for a CEI. It establishes the compatibility of the design approach with the technical requirements. Cost and schedule are reviewed and formal identification of specific engineering documentation which defines technical requirements are approved and at PDR completion of the Part I CEI is baselined or rebaselined as appropriate.

The CDR is a formal review, the technical design of a CEI is conducted. In general, the baseline is not changed as the Part I specification continues as the primary document. The product baseline is defined as CDR using specific engineering documentation released to manufacturing of the selected CEI unit.

The CI Product Configuration is established for the CEI. This inspection is performed on a unit selected by the customer. The prime objective is to formally accept Part II CEI specification as an audited and approved document. Secondly it provides a precisely known baseline against which changes may be proposed and evaluated. The Part II detail specification as audited and accepted at CI, remains in effect for the remainder of development/operations and serves as the basic document for Configuration Management.

6. SUBCONTRACTOR/VENDOR CONFIGURATION MANAGEMENT CONTROL

Major subcontractors on HIMSS will be required to submit configuration management plans to Hughes. This configuration management plan will be in compliance with customer requirements. The Configuration Manager will ensure that each selected subcontractor or vendor has the appropriate policies and procedures to implement all imposed configuration management requirements. The policies and procedures will ensure thorough and accurate product identification, configuration control, and status accounting. Figure 6-1 illustrates the configuration management relationship.

6.1 Product Identification

The responsible engineering activity will determine allocated requirements for each subcontractor or vendor procurement. This is usually done by preparation of procurement specifications for subcontract-developed items. The CMO will ensure that the remaining items of product identification are procured and submitted in a schedule compatible with program requirements. A procurement statement of work (SOW) and a subcontract data requirements lists (SDRL) are used to specify the requirements for drawings and other items of product identification.

Vendor items are normally procured in accordance with the vendor's catalogs and specifications, although a source control drawing may be required. Again, depending on the vendor item, a SOW and SDRL (Attachment 4) may be required to complete the procurement package.

6.2 Configuration Control

Each procurement will require change control procedures compatible with the prime contract requirements but tailored to the magnitude and scope of the procurement. Hughes utilizes a set of procurement change control clauses to ensure a consistent approach when a subcontract CM plan is not specified. These clauses define in detail subcontractor requirements for the preparation, submittal, and approval of Class I and Class II engineering changes as well as deviation and waiver submittals.

Hughes procedures for change control of procurement specifications and source control drawings are delineated in Section 4 of this plan. In general, all subcontract changes requiring Hughes approval will receive CRB or subsystem approval action as appropriate.

6.3 Configuration Status Accounting

In all procurements, Hughes attempts to maximize the use of subcontractor/vendor data and formats with minimal change, to reduce program costs. To this end, the Hughes CMO will review each

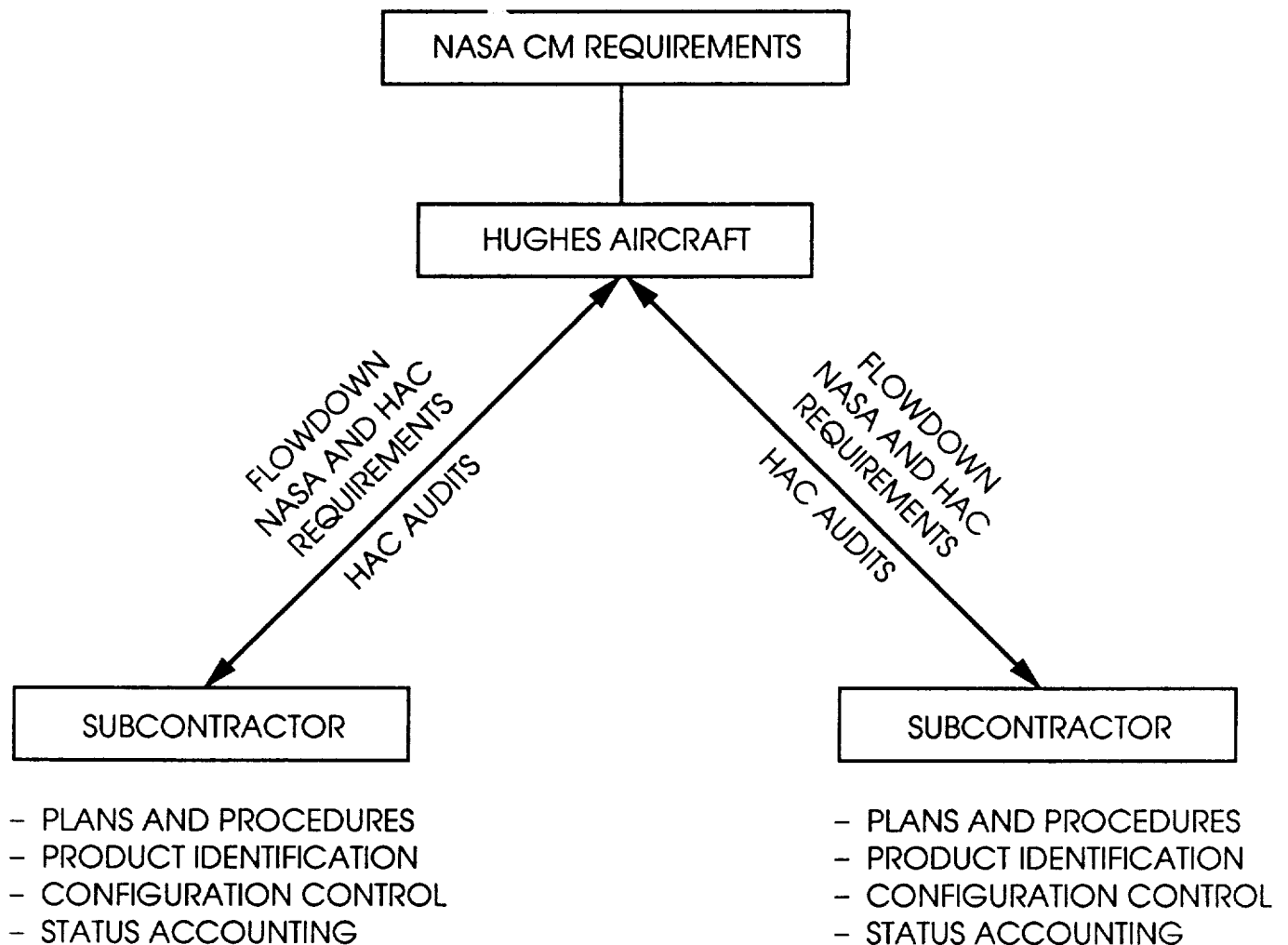


FIGURE 6-1. SUBCONTRACTOR CONFIGURATION MANAGEMENT FLOWDOWN REQUIREMENTS

subcontract to assure that the necessary data and subcontract/vendor formats are compatible with the prime contract requirements. This data must support the physical and functional audits as well as the functional configuration audit, which is a prime Hughes responsibility.

The Scope of subcontract/vendor status accounting reports is dependent on the procurement, but the following status information will be required for each subcontract-developed items:

- Indentured Drawing List
- Nonconformances (Minor Waivers)
- Deviation/Waiver Report
- Approved Engineering Change Summary
- Product Baseline Drawing/Specification Revision Status
- As-built Product Verification Report

7. PROGRAM PHASING

The Configuration Management Plan will be phased to be compatible with the HIMSS Program Master Schedule. Configuration Management milestones and program milestones have been identified in Figure 7-1. (Sample HIMSS Program Master Schedule). Program milestones and their relationship to program baselines are depicted in Figure 3-1. Any changes in the program milestones will necessitate corresponding changes in timing of the configuration management milestones.

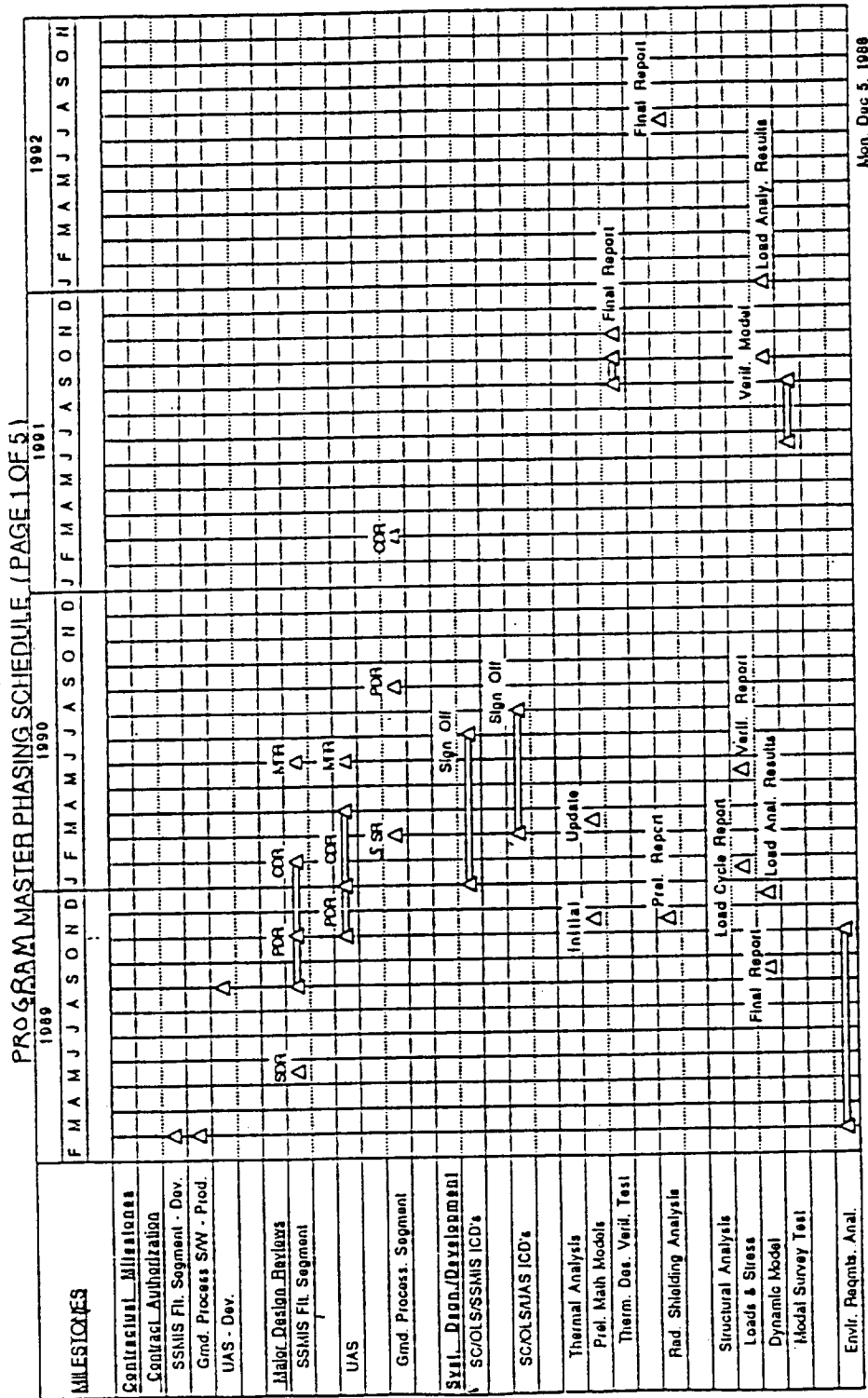


FIGURE 7-1. SAMPLE HIMSS PROGRAM MASTER SCHEDULE

8. MANAGEMENT INTEGRATION OF CONFIGURATION MANAGEMENT

The Program Manager is responsible for the HIMSS program. He/she has empowered the Configuration Manager to implement a configuration management plan which complies with MM 8040.12A, all exhibits (I through XIII). The Configuration Manager reports directly to the Program Manager.

The Configuration Management Office is the single function assigned responsibility to plan, develop, administer implement and maintain configuration management policies of operation for the HIMSS program. Functions of program elements as they relate to Configuration Management are described in the following paragraphs.

8.1 System Engineering

System Engineering is responsible for review of all design documents. The responsibility includes design review leading to establishment of baselines and verification of specified performance for the Systems Requirements Review (SRR), Preliminary Design Review (PDR), Critical Design Review (CDR), Flight Readiness Review (FRR), and any others reviews required by the customer. The Configuration Manager interfaces with Systems Engineering by supporting the reviews with release documents and providing administrative/technical assistance as required.

8.2 Design Engineering

In the basic fulfillment of the design task, Engineering is responsible for the compliance of technical documentation with contract requirements. Compliance with the Configuration Management requirements for specifications, drawings, and other configuration controlled documents, and the application of controlling numbers are the responsibility of this organization.

Design Engineering is the major contributor to the engineering change process for approval as well as documentation of approved changes. Specific Responsible Engineering Activities (REAs) are assigned to each subsystem. They are responsible for the specifications and drawings, and as such, are responsible for reviewing proposed changes to determine the effect on those documents. Each REA has a Document Control Center (DCC) tasked with controlling the initial release and changes to all documents under his responsibility. Each DCC is responsible for inputting engineering parts listings into the Engineering Data Release System (EDRS), releasing drawings and changes through EDRS and maintaining the parts list and configuration status in the EDRS data base.

8.3 Software Development

Software development for HIMSS is the responsibility of the Software Manager. the configuration manager is responsible for

controlling the release and changes to software and software documentation. The software manager or his designee reviews all proposed hardware changes for their effects on software and notifies the configuration control board in a manner analogous to that of the hardware REA. System Engineering verifies compliance with specifications and the software manager verifies compliance with software requirements.

8.4 Subcontracts Management

It is the responsibility of the Materiel organization to include requirements for configuration management within subcontract Statements of Work, Subcontract Data Requirements Lists (S DRL), and purchase orders. Configuration Management, Engineering, and Quality Assurance organizations verify the requirements flow down through review of those subcontractor documents. Major subcontractors on HIMSS will be required to submit configuration management plans to Hughes. The application of configuration management practices is to be commensurate with the criticality of the subcontracted item.

8.5 Quality Assurance

Verification and certification that the hardware or software item is in conformance with all its requirements is one of the prime functions of Quality Assurance. Therefore, Quality Assurance is responsible for ensuring accurate compliance to drawing, specification, test plan, test procedures and configuration requirements. Quality Assurance forwards hardware and software as-built and usage records to the HIMSS Configuration Management Office.

8.6 Contracts

Contracts is responsible for the contract documents and their inclusion of configuration management interfaces between Hughes and NASA. All Class I changes and engineering change proposals (ECPs) are submitted by Contracts. After approval by NASA, the ECP becomes a contract change document and is forwarded to Contracts for dissemination and compliance monitoring.

8.7 Engineering Data Control

Engineering Data Control (EDC) is a central service organization that provides a single source for engineering release, documentation status and cataloging, and configuration status data input and output. EDC operates the document release center, verified parts listing and configuration change status through the EDRS computer data base, and releases documents and makes distribution. EDC also provides catalog data and all reports generated from the EDRS computer-based systems. These activities are performed under the direction of the Configuration Manager.

8.8 Subcontractor/Vendor Interfaces

Requirements for data to be furnished by a supplier are established by the SDRL or are incorporated as a part of the purchase order Statement of Work. The Configuration Manager verifies the adequacy of subcontractor and vendor contractual data requirements and assists in identifying the data necessary to satisfy the needs of the program. The Configuration Manager reviews and approves subcontractor and vendor Statements of Work and purchase orders and monitors subcontractor/vendor compliance with their plans. The system for controlling subcontractor and vendor data provides for delivery of documentation to the Configuration Manager, who then coordinates the review and approval of the incoming data and provides a status report to the Program Manager.

The Configuration Manager participates in Quality Assurance audits of major subcontractors and verifies their configuration management system capability to provide all required data in a timely manner. To ensure maximum responsiveness and effectiveness, subcontractors must have a responsible configuration manager. Each major subcontractor will be required to submit a configuration management plan to Hughes.

9. CONFIGURATION MANAGEMENT REVIEWS

9.1 Design/Program Reviews

The reviews to be conducted on the HIMSS program are significant configuration management events. The CM Office assists in the planning and preparation for system level design reviews. The major program reviews are listed below:

- System Requirement Review (SRR)
- Program Requirements Review (PRR)
- Preliminary Design Review (PDR)
- Critical Design Review (CDR)
- Flight Readiness Review (FRR)
- Monthly Status Review
- Configuration Inspection (CI)
- Design Certification (DC)
- Final Acceptance Review (FAR)

The data submittal timetable for these flight Assurance Reviews (except Monthly Status Reviews), is as follows:

Agenda:	30 days prior to the review
Full Package:	15 days prior to the review (OGE data 10 days prior)
Review Vugraphs	At the review (1 copy for each NASA or designated representative attending)

10. DATA MANAGEMENT DOCUMENTATION MAINTENANCE

The HIMSS data management procedures are a refined management system that will provide cost-effective preparation, control, maintenance, revision, and delivery of data elements. This system has been utilized by Hughes with continued refinement to policies and procedures.

The HIMSS Configuration Manager is also responsible for all data management activities. All data management activities are integrated into the configuration management process which enhances communication, data exchange, and efficient utilization of configuration and data management personnel.

10.1 Data Identification, Control, and Accounting

The terms identification, control, and accounting are usually applied as discrete configuration management functions, although they are equally applicable to HIMSS data management tasks.

10.2 Contractual Data Requirements

The Hughes Contract Data Requirements List (CDRL) is the primary data management tool for identifying and controlling data item submittals. This calendarized list establishes preparation responsibility, format/content requirements, contractually required quantities, data acceptance/review categories, and the contract recipient as well as required delivery dates.

The CDRL is issued to all program personnel having the responsibility for data preparation.

Attachment 3 to this plan is a sample CDRL, which will reflect the RFP data requirements. Calendarization data submittal requirements will be established during the course of the entire program. The CDRL will be revised to reflect any changes during contract negotiations, and subsequent contractual changes as directed by NASA.

Three-month windows of data submittal requirements will be extracted from the schedule to establish near-term events for data authors.

Updated versions of the entire CDRL to reflect internal reprogramming on changes to incorporate contractual direction will be supplied on an as required basis. These updates will also depict data submittal performance in the schedule system.

All contractually required data will be reviewed and authorized for submittal to NASA by designated program functions to assure compliance with contract requirements. These reviews for technical adequacy, accuracy, and content are denoted by approval signatures

on all documentation.

Requirements for legibility, quality, format, and on-time submittal will be controlled by the Configuration Manager and his staff. The HIMSS Data Configuration Office will establish and maintain files of completed data submittals, inspection records, transmittal documentation, and customer responses. A detailed record of each data submittal will be established to show data identification and customer approval status.

A publication date is entered in the CDRL when the document is submitted to NASA. The Manager will be responsible for coordinating preparation efforts and for quality control. Remedial and/or corrective action will be taken by the REA or staff when submittals fail to meet technical inspection criteria. The Configuration Manager will verify that all customer comments are incorporated in revised/resubmitted documents.

The Hughes/Customer data flow is illustrated in Figure 10-1.

10.3 Data Center

The HIMSS data center is charged with the responsibility to identify and store all program data for future use and potential submittal. Files are maintained for correspondence (incoming, internal, and outgoing), documentation.

The HIMSS Data Management Office will assign unique program data identification numbers. Program data items (other than configuration control items, specifications, engineering drawings, etc.), will be identified by a unique HIMSS program designation, followed by four-digit suffix (file number) that identifies the specific data item. The data number structure is illustrated below:

Single Issue
Document

HS123-4567A

First Revision

Multiple Issue
Document
(Example: Monthly
Report)

HS123-4567-1

Issue Number

File Number

HIMSS Program
designation

10.4 Program Instructions

Program instruction (PI) prepared for HIMSS requirements will be assigned data identification numbers. The HIMSS Program Instruction Manual will be controlled, revised, maintained, and distributed by the Data Management Office.

The data files for all HIMSS program instructions are kept together in the data bank center to create a single source for accountability.

10.5 System Test Data

The HIMSS Data Management office will function as a repository for all HIMSS test data. All test data are identified by spacecraft unique test sequence, phase, and procedure number. This identifier is entered into a system test data file. Test data includes test procedure data masters, line printer data, analog recorder data, and magnetic tape. Retests and special requested tests are authorized and conducted to defined test requirements.

Records of all system test data will be maintained in the HIMSS computer files to allow thorough test data searches. HIMSS test data can be retrieved from data files by subsystem, assembly level, part numbers, test numbers, test phase, and data submitted to the customer.

10.6 Photography Management

The HIMSS program requirements for photography will be in fully compliant with customer requirements.

The HIMSS Data Management Office will be the repository for all photography data. The DM office will maintain a computerized photo file by program for real time access.

Photography quality will be continued by using 4 inch by 5 inch negative film (HI-Resolution) and the use of SCG photo personnel. The use of 4 by 5 inch negatives enables enlargements to be used in failure analysis.

The photography data base will be verified during hardware audit and buyoff meetings. All photos will contain hardware identification numbers and physical size information to facilitate accountability. All requests to deviate from initial requirements will be channeled through the Program Office for customer concurrence/approval.

10.7 Subcontractor Data Management

A Make or Buy Plan will be generated. The Configuration Manager will coordinate with the responsible functional activities

and Subcontractor Administrator to jointly define subcontractor data requirements. These requirements will be specified in each subcontract SOW, and the HIMSS Configuration Manager will prepare a subcontract CDRL that will be included in all the subcontract procurement packages. Typical data requirements identified are data description, data preparation instructions, and data submittal schedule and quantity. Figure 9-2 depicts this process.

The Subcontract Administrator will coordinate the flow of all SDRL data to the Data Management Office to establish program receipt of SDRL data items, monitor the schedule performance and coordinate with functional activities for review of data. A record of actual subcontract document delivery dates will be kept to identify discrepancies with scheduled delivery dates. Corrective action will be taken by the Configuration Manager when submittals fail to meet schedule criteria. The HIMSS Configuration Manager will actively participate in all reviews to ensure that all data are in compliance with NASA or Hughes requirements. Approved data will be distributed to the various user organizations and copies filed for permanent retention and retrieval.

ATTACHMENT 1. HIMSS MASTER INDEX (SAMPLE)

ATTACHMENT 2. HIMSS EQUIPMENT SCROLL (SAMPLE)

SSMIS FLIGHT EQUIPMENT SCROLL									
No.	Description	Responsibility	Grd. Board	Eng. Mtd	Prot. No. Per	Design	Material	STE/Test	Make/Buy
1	MECH/HIMSS CONTROL	Richard Johnston			1	Existing	SSM/J	STE	Make
2	DAFJA	Richard Johnston			1	Existing	SSM/J	Shipping Container	Buy
3	Mounting	Richard Johnston			1	Existing	SSM/J	Fat Contols	Buy
4	Shelf	Richard Johnston			1	Existing	SSM/J	Moler Test Fixture	Buy
5	Holer	Richard Johnston			1	Existing	SSM/J	Fat Test Fixture	Buy
6	Eca	Richard Johnston			2	Existing	SSM/J	Torque Test Fixture	Buy
7	Basilog	Richard Johnston			2	Existing	SSM/J		Buy
8	HP Cads	Richard Johnston			2	Existing	SSM/J		Buy
9	MITERIA DEPLOYMENT MECH								
10	Antenna Structure	Richard Johnston	1	[Note 1]	1	Existing	SSM/J	Fat Fixture	Buy
11	Actuator	Richard Johnston	1		1	Existing	SSM/J	Fat Fixture	Buy
12	Sieve Lin	Richard Johnston	1		1	Existing	SSM/J	Fat Fixture	Buy
13	Launch Lock	Richard Johnston	2		1	Existing	SSM/J		Buy
14	Torsion Springs	Richard Johnston	6		6	Existing	SSM/J	Torque Testing	Buy
15									
16	SENSOR DEPLOYMENT MECH								
17	Actuator	Richard Johnston	1		1	Existing	SSM/J	Torque Fixture	Buy
18	Sensor Frame	Richard Johnston	1		1	Existing	SSM/J	Fat Fixture	Make
19	Lock Pin	Richard Johnston	2		2	Existing	SSM/J		Make
20	Torsion Springs	Richard Johnston	6		6	Existing	SSM/J	Torque Test	Buy
21									
22	WIRING HARNESS								
23	Spinning Harness	Richard Johnston	1		1	Mod/E list	SSM/J	Fac Test	Make
24	Dispun Harness	Richard Johnston	1		1	Mod/E list	SSM/J	Fac Test	Make
25									
26	STRUCTURE								
27	Interface Plate	Richard Johnston			1	Mod/E list	SSM/J	Alignment	Make
28	Structure Rib	Richard Johnston			3	Mod/E list	SSM/J	Fixture	Make
29	Top Ring	Richard Johnston			1	Mod/E list	SSM/J		Make
30	Base Plate	Richard Johnston			1	Mod/E list	SSM/J		Make
31	Top Cover	Richard Johnston			1	Mod/E list	SSM/J		Make
32	Side Cover	Richard Johnston			3	Mod/E list	SSM/J		Make
33									
34	CALIBRATION LOAD ASSY								
35	Hot Load Bin	Richard Johnston	1		1	Existing	SSM/J		Make
36	Cold SSV Bin	Richard Johnston	1		1	Existing	SSM/J		Make
37	Dispun Plate	Richard Johnston	1		1	Existing	SSM/J		Make
38									
39	THERMAL DIAPHERS								
40	Spinning Binhet	Richard Johnston	1		1	Mod/E list	SSM/J	Sensor Mock Up	Make
41	SDM Binhet	Richard Johnston	1		1	Mod/E list	SSM/J	Sensor Mock Up	Make
42	Interface Binhet	Richard Johnston	1		1	Mod/E list	SSM/J	Sensor Mock Up	Make
43	Hot Load Binhet	Richard Johnston	1		1	Mod/E list	SSM/J	Sensor Mock Up	Make
44									

NOTE 1: Engineering Model Included In Breadboard

11/21/88

HIMSS EQUIPMENT SCROLL (SAMPLE)

ATTACHMENT 3. HIMSS CONTRACT DATA
REQUIREMENTS LIST (CDRL) (SAMPLE)

ATTACHMENT 4. HIMSS SDRL (SAMPLE)

HUGHES

SUBCONTRACT DATA REQUIREMENTS LIST (SCDRL)

(1) DATE: MAY 1981 (4) SOW NUMBER: (5) REP/CONTRACT NO: (6) PREPARED BY: H. CHASS

(2) PROGRAM TITLE: (3) SUBCONTRACT ITEM:

NUCLEAR INCREASED COMPLEX																			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
DO FORM LINE NO	AS OF DATE	AS OF DATE	AS OF DATE	AS OF DATE	AS OF DATE	AS OF DATE	AS OF DATE	AS OF DATE	AS OF DATE	AS OF DATE	AS OF DATE	AS OF DATE	AS OF DATE	AS OF DATE	AS OF DATE	AS OF DATE	AS OF DATE	AS OF DATE	AS OF DATE
INITIAL DESCRIPTION OF DATA																			
Configuration Verification List																			
1																			
2																			
3																			
4																			
5																			
6																			
7																			
8																			
9																			
10																			
11																			
12																			
13																			
14																			
REMARKS																			
To be included with Items 17 and 18.																			
Hughes form DOD-STD-480A.																			
See PO Attachments CC-1-3- DOD-STD-480A.																			
Microfilm aperture cards.																			
*21 days prior to each design review.																			
*Review plus 15 days.																			
To be included in Item 5, Item 18, and Item 21.																			
To be included in Item 5; CUR																			
Preliminary government owned equipment with proposal, final 30 days ARD.																			
To be included with Item 18.																			
To be included with Item 18, use DPI 09 and 10.																			
Use DPI/COES 10.																			
Use DPI/PE-11C.																			
NOTE: Data items shall be at original quality for system requirements or meet 60-sec per inch, 100 lines per inch, and 100 lines per inch, 1																			

4.4 SOFTWARE IMPLEMENTATION PLAN

HUGHES

Space and Communications Group

GOVERNMENT ELECTRONICS SYSTEMS DIVISION

HS256C-1045-0057

SOFTWARE IMPLEMENTATION PLAN

**FOR THE
HIGH RESOLUTION MICROWAVE
SPECTROMETER SOUNDER
(HIMSS)
INSTRUMENT PROGRAM**

**AN INSTRUMENT FOR NASA'S
EARTH OBSERVING SYSTEM**

PRELIMINARY

OCTOBER 1990

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HIMSS SOFTWARE IMPLEMENTATION PLAN

1.0 INTRODUCTION

In order to perform the required tests on the HIMSS instrument and its interfaces to the Eos Platform, a computer is used to control the system test equipment (STE). The software written for this computer is the only software required by the HIMSS program. This document describes the methodology Hughes will use to produce the STE software and covers both the management and the technical approach. Not covered in this document are any of the following:

- 1) The STE equipment, both hardware and firmware
- 2) Interfaces from the STE computer to the STE hardware
- 3) Commercially available software that may be installed on the STE computer, such as compilers, word processors, editors, etc.
- 4) Ancillary special purpose software used for analysis of stored data
- 5) Software used for HIMSS testing at the subsystem, unit, and lower levels

1.1 List of Acronyms

CDR	Critical Design Review
Eos	Earth Observing System
ECR	Engineering Change Request
FQT	Formal Qualification Test
HIMSS	High Resolution Microwave Spectrometer Sounder
NASA	National Aeronautics and Space Administration
PDR	Preliminary Design Review
PRF	Problem Report Form
PQT	Preliminary Qualification Test
SDF	Software Development File
STE	System Test Equipment
SRD	System Requirements Document
SRR	Software Requirements Review
TBD	To Be Done/Determined
TBR	To Be Reviewed
TBS	To Be Supplied
TCR	Test Completion Review
TRR	Test Readiness Review

2.0 APPLICABLE DOCUMENTS

The following documents form a part of this specification to the extent specified herein. Specifications in this document shall supersede any disagreements found between it and any of the documents referenced below. The Hughes Company Practices referenced below are attached in their entirety to this plan as an appendix.

GSFC-415-Eos-00004	Earth Observing System Performance Assurance Requirements for General Instruments
HS256C-1045-0060	HIMSS Verification Plan
HS256C-1045-0055	HIMSS Performance Assurance Plan
HS256C-1045-0056	HIMSS Configuration Management Plan
Hughes Practice 5-0-6	Software Management
Hughes Practice 6-10-0	Configuration Management
Hughes Practice 19-60-00	Software Quality Assurance

3.0 MANAGEMENT APPROACH

3.1 Management Responsibilities

3.1.1 Overall Responsibility

The overall responsibility for production of the HIMSS STE software lies with the HIMSS performance assurance manager.

3.1.2 Software Development

Development of the STE software will be the responsibility of the HIMSS system engineering manager, who will ensure completion of the following:

- 1) Provision a software development plan and software standards and procedures for software design and development
- 2) Definition of software to be developed based on planned system test activities
- 3) Definition of system test requirements by creating a system test software requirements document
- 4) Design and coding of all programs, subprograms, modules, module interfaces, man-machine interfaces, and interfaces from the target computer to the test equipment
- 5) Preparation of packages required for reviews
- 6) Preparation of the programmer maintenance manual containing detailed functional descriptions, design documentation, interface descriptions, and code listings
- 7) Preparation of the system test user's guide

3.1.3 Quality Assurance

Quality assurance will be the responsibility of the HIMSS product assurance manager, who will ensure completion of the following:

- 1) Provision of a performance assurance plan for the HIMSS STE software
- 2) Collection of all problem reports (PRFs) and engineering change requests (ECRs) and tracking through completion and test

3.1.4 Configuration Management

Configuration management will be the responsibility of the HIMSS

configuration/data management manager, who will ensure completion of the following:

- 1) Provision of a configuration management plan for the HIMSS STE software
- 2) Assembly and maintenance of a library containing all current requirements, standards, design documentation, code listings, and user documentation
- 3) Maintenance of machine-readable copies of the most current code baseline
- 4) Procurement, installation, and control of any commercial software used on the STE computer

3.1.5 Testing and Use

The responsibility for testing and use of the HIMSS STE software will belong to the system integration and test manager, who will ensure completion of the following:

- 1) Provision of an STE software test plan and test procedures with a matrix associating each requirement with a test item to be performed
- 2) Verification of STE software performance against stated requirements by conducting all of the tests required by the test procedures
- 3) Reporting of all problems and requested changes through the specified change control process
- 4) Using the STE software to conduct tests as required by the HIMSS Verification and Plan

3.2 Management Mechanisms

3.2.1 Requirements Development and Control

Hughes will employ top-down structured design principles for the design and development of the HIMSS STE software. This approach begins with the definition of software requirements, which are derived from the specific testing tasks described in the HIMSS Verification and Calibration Plan and will be documented in the Software Requirements Document (SRD). As the test software proceeds through functional specification and preliminary design, requirements will be levied on elements of the hierarchical software structure. After the SRD is reviewed and validated at the preliminary design review (PDR), it will be placed under configuration control. Any changes to the SRD will require formal change control documentation and approval of the performance

assurance manager.

3.2.2 Schedule Development and Control

The development schedule is driven by the need to have the HIMSS test software available in final configuration to support specific testing tasks. Through an iterative process involving management and the responsible software engineers, the degree of difficulty of each software item will be assessed and the required amount of lead time established. Sufficient margin will be incorporated into the schedule to ensure that no delays in HIMSS testing and delivery will occur. After the PDR, when requirements have been finalized and preliminary designs completed, a final schedule will be established. The HIMSS performance assurance manager will be responsible for producing the schedule as well as ensuring that all major milestones are met.

3.2.3 Internal Reviews

Internal reviews are considered those reviews attended by personnel who are directly involved with the HIMSS test software development effort. NASA personnel are invited to attend.

Internal reviews are generally informal in nature and can be convened by any of the following: the performance assurance manager, the system engineering manager, the product assurance manager, or the system integration and test manager. These reviews shall not necessarily constrain the start of the next step and will be cost-effective, using only those items necessary to the review. These reviews are generally held to verify that module milestones have been met and that the appropriate technical objectives have been considered in the completion of the milestone.

3.2.3.1 Software Requirements Reviews

Before, and again after, the Preliminary Design Review, a software requirements review (SRR) will be held, at which the preliminary and final SRD will be reviewed to determine that HIMSS testing objectives have been properly translated into STE software requirements.

3.2.3.2 Test Readiness Review

Upon completion of the development effort, a test readiness review (TRR) will be held to verify that the software successfully implements the design approved at the CDR, meets all applicable standards, and is ready for formal testing. A package will be prepared for this review containing the following information:

- 1) Listing of all source code annotated to the level specified by the software standards and practices section of the SRD.

- 2) Design and interface control documentation
- 3) Completed test plan and test procedure for the HIMSS test software
- 4) Flow diagrams updated from the CDR, as necessary
- 5) The completed user's manual

3.2.3.3 Test Completion Review

After formal testing, the test completion review (TCR) will be held to verify that all software requirements have been met and that the software is available for use to test the HIMSS instrument. Upon the completion of this review, the software (both source and executable) and all supporting documentation will be placed under configuration control as required by Hughes Company Practice 6-10-0 (Configuration Management). Section 3.4 of this document describes, in more detail, the configuration management policies to be applied for controlling and maintaining baselines of the HIMSS STE software.

3.2.4 External Reviews

External reviews are generally formal in nature and considered necessary to the start of the next task. These reviews are expressly held to allow unbiased questions and suggestions from personnel within NASA and Hughes not directly involved with the program.

3.2.4.1 Preliminary Design Review

The second external review is the preliminary design review (PDR), which is the vehicle used to examine the design and verify that the design satisfies all of the requirements of the SRD. A design review package will be assembled that contains the following information:

- 1) Detailed software design specifications that allocate each requirement to a software function
- 2) Processing flow diagrams that identify each major software function in a logical flow that meets the software requirement
- 3) User information that identifies operator/user interfaces

Each of these items will comply with the requirements of Hughes Company Practice 5-0-6 (Attachment B - Software Document Formats).

3.2.4.2 Critical Design Review

Upon completion of the detailed design, the critical design review (CDR) will be held, which is the vehicle used to verify that the software design satisfies the detailed requirements contained in the final SRD. A design package will be assembled for the CDR containing the following:

- 1) Detailed processing flow diagrams that identify each function to the smallest element of the application software
- 2) A preliminary test plan defining the tests required to integrate the software and verify performance against the SRD
- 3) Software development files and preliminary user's manuals, as appropriate
- 4) Interface and data base documents with file formats, structures, and data specified

Each of these items will comply with the requirements of Hughes Company Practice 5-0-6 (Attachment B - Software Document Formats).

3.3 Documentation Requirements

Table 3-1 lists all documents required for the HIMSS test software, as well as the personnel responsible for preparing each document and the review at which the document will be approved.

Table 3-1

HIMSS STE Software Documentation

Document -----	Responsibility -----	Reviewed at -----
Preliminary SRD	System engineering manager	SRR #1
PDR package	Lead software engineer	PDR
Final SRD	System engineering manager	SRR #2
CDR package	Lead software engineer	CDR
Software development file	Lead software engineer	TRR
Test Plan	System integration and test manager	TRR
Test Procedures	System integration and test manager	TRR
User's manual	System integration and test manager	TCR
Programmer maintenance manual	Lead software engineer	TCR

3.4 Configuration Management

Configuration management of the HIMSS STE software will comply with GSFC-415-Eos-00004 (Earth Observing System Performance Assurance Requirements for General Instruments) and Hughes Company Practice 6-10-0 (Configuration Management).

3.4.1 Baselines

Upon the completion of each review, a baseline will be established and placed under configuration control. This baseline will include all material approved at that and all previous reviews. Table 3-2 lists each review and the material baselined at each. The HIMSS configuration/data management manager will be responsible for impounding a copy of each baseline after the review in which it is established. Each baseline will serve as the starting point for the next. Baseline versions stored on machine-readable media will be clearly marked with an adhesive label and stored in a locked cabinet, not located near any equipment generating strong magnetic fields, to prevent loss, damage, or inadvertent removal.

Table 3-2

Baseline Contents for Each Review

Review Name -----	Review Type -----	Baselined Material -----
SRR#1	Internal	Software requirements document
PDR	External	Preliminary design documentation
SRR#2	Internal	Software requirements document
CDR	External	Detailed design documentation Interface documentation
TRR	Internal	Test plan Test procedures
TCR	Internal	Code (source and executable) User's manual Programmer maintenance manual

3.4.2 Software Changes

All prospective changes to the HIMSS STE software, once a baseline is established, will require an Engineering Change Request (ECR), which may or may not be the result of completing a problem report (PRF). The basis for managing changes to the HIMSS STE software will be a determination of the changes' classification. The classifications are defined as follows:

- 1) Class 1 software changes are those which affect system requirements, software requirements, system safety, reliability, cost, schedule, or internal interfaces.
- 2) Class 2 changes are those which have no impact on STE software operation and are transparent to the user. An example of a class 2 change would be the addition or modification of comment lines in the source code.

For Class 1 changes, a review will be held which will be attended by the HIMSS performance assurance, system engineering, product assurance, configuration/data management, and system integration and test managers and to which NASA personnel will be invited. The proposed change will be examined in detail, and test requirements and procedures will be defined. Approval of the change will require concurrence of NASA representatives and the HIMSS managers listed above. For Class 2 changes, the system engineering and product assurance managers will be present at a review to evaluate the proposed change and decide testing strategies. NASA will be informed of Class 2 changes at the monthly status report. All nonconformance reports and descriptions of corrective action will be included in the appropriate Software Development File (SDF).

3.5 Quality Assurance

In general, quality assurance for the HIMSS STE software will involve verification that the software meets the requirements of the SRD, as well as all applicable standards, policies, and practices, including compliance with GSFC-415-Eos-00004 and Hughes Company Practice 19-60-00 (Software Quality Assurance). To perform this task, the HIMSS product assurance manager will (a) attend all internal and external reviews to verify that all required documentation has been completed, and (b) obtain listings of all source code before it is baselined and verify compliance with all standards. Before the Test Readiness Review, the test plan, test procedures, and requirements vs. test items matrix will be reviewed to verify that all STE software requirements will be tested. The HIMSS product assurance manager, or a designated substitute, will witness both the PQT (Preliminary Qualification Test) and the FQT (Formal Qualification Test) to verify that the tests described in the test procedures are actually run. Notes will be made to indicate the times of each test and any anomalies encountered.

After the PQT, and again after the FQT, the test output will be examined to verify that each requirement has been successfully tested. All deliverable documentation will be reviewed for compliance with applicable standards.

As required by Hughes Company Practice 19-60-00 (Software Quality Assurance), a trend analysis will be performed in which data on corrective actions will be analyzed to detect any adverse trends. NASA will be provided with the results of this trend analysis, along with the raw data on corrective actions, at the monthly status briefing.

4.0 TECHNICAL APPROACH

4.1 STE Computer Requirements and Constraints

The STE computer (manufacturer and model TBS) will be equipped with sufficient memory (TBS K) to load the STE software and support its execution. A printer (manufacturer and model TBS) will be provided for hardcopy.

The STE computer will have provision for a clock and battery capable of tracking the date and time for one month without applying external power to the STE.

Data storage will be provided by removable hard disk cartridges of at least 10 Mbyte capacity. A dual floppy disk drive will be provided to support backup STE operation and data storage in the event of difficulties with the hard disk drive. Commercial software (text editors, compilers, etc.) will be installed on the STE computer to support both STE software development and HIMSS testing.

4.2 STE Software Description

The STE software will allow interactive display and modification of both control and status information. A simple and efficient user interface will be provided, with all related information grouped together on the screen and selection of values to be modified accomplished with the use of a cursor or mouse. Where appropriate, pull-down menus will be used with on-line help facilities to reduce the need for extensive referencing of manuals during HIMSS testing. Measured STE variables will be displayed, and HIMSS test engineers will be warned of out-of-limits conditions by both audible warnings (repeated tones or "beeps" generated by the STE computer using its internal speaker) and special screen displays. Illegal inputs will be flagged and error messages displayed, ensuring that (a) the HIMSS is not damaged by inadvertent or deliberate control inputs that might generate harmful conditions, and (b) the STE software is protected from failure and any consequent loss of test data.

Storage of test inputs and results will be accomplished by saving, at a time interval selected by the HIMSS test engineer, the entire set of status and control words into a file. The time interval for data storage will be at least once per day. The file will be stored incrementally (appended to with each new set of values) so that the saved data can be later recovered in its entirety. Provision will also be made to dump the control and status information to the printer, or to print previously stored data.

4.3 Software Design

The design of the HIMSS STE software will be performed in a top-down manner with the logical structure being driven by the requirements of specific HIMSS testing tasks, as described in the SRD. A preliminary design will be developed upon completion of the preliminary SRD, and will be reviewed at the PDR. After the final SRD is approved, detailed design will commence and will be reviewed at the CDR.

4.4 Software Development

Coding will begin upon approval of the detailed design at the CDR and will finish with the Test Readiness Review, which is the vehicle for verifying that the design has been successfully implemented. Day-to-day control of the coding process will be the responsibility of the cognizant programmer, with periodic informal reviews conducted by the system engineering manager.

Software development files (SDFs), maintained by the responsible programmers, will provide a uniform and visible collection point for all documentation and code associated with each unit. The SDF provides an orderly and consistent approach for the development of each unit and will aid individual discipline in the establishment and attainment of unit level schedules. Figure 4-1 is the SDF cover sheet required by Hughes corporate policies and practices and lists the required information.

The HIMSS STE software will be written in a high-level language (e.g., Ada, C, or FORTRAN), except where performance requirements necessitate the use of assembly language. The code will be produced in a top-down, incremental fashion to minimize integration efforts and will be developed in units. A unit is a routine or group of logically related routines, with each routine typically less than 100 lines of high-level code. Provision shall be made to use a high-level language for generation of special applications programs for analysis of previously stored data.

Development of the HIMSS STE software will comply with Hughes Company Practice 5-0-6 (Software Management/Engineering).

Figure 4-1
Standard Hughes SDF Cover Sheet

4.5 Software Testing

Testing of the HIMSS STE software will begin after the Test Readiness Review and will be concluded when all requirements in the SRD have been verified and the Test Completion Review held. All testing will be carried out in accordance with the test plan and procedures, which describe in detail the actions to be carried out for each test.

The testing will be conducted against the HIMSS breadboard hardware during the electrical assembly demonstration test. This hardware will be electronically equivalent to the HIMSS instrument.

4.5.1 Unit Testing

As units are coded, unit level testing will be conducted by the cognizant programmer, in which requirements allocated to the unit level will be verified. Every instruction will be executed at least once. All options at each branch point will be verified and input/output at the unit level will be tested for illegal ranges and formats. After units have been individually tested, they will be released for system integration. Release of software units will establish a software baseline.

4.5.2 Integration Testing

After units have been individually tested and released, they will be integrated into a cohesive executing system. This system will be tested, under the control of the lead programmer, to verify that all interfaces between units and modules are managed correctly and that the overall functionality satisfies the requirements of the SRD. An informal review under the direction of the system integration and test manager will be held at the completion of integration testing.

4.5.3 Acceptance Testing

Acceptance testing for the HIMSS STE software will take place in two phases. The first test will be the Preliminary Qualification Test (PQT), which will be performed by the lead software engineer and during which corrections of errors and anomalies are permitted. The second test will be the Formal Qualification Test (FQT), performed by an independent Hughes organization separate from the HIMSS program, which must be a flawless demonstration that the STE software satisfies all requirements. The system test and engineering manager, as well as the product assurance manager, or their representatives, will be present during the FQT to verify successful completion.

4.5.4 Delivery

Delivery will take place upon completion of acceptance testing and after the Test Completion Review is held. All deliverable software and documentation, including listings, machine-readable source and executable code, SDFs, test data, the user's manual, and any other material will be placed in the data bank for archive and distribution per contractual requirements.

4.6 Maintenance

The HIMSS STE software will be placed under formal software change control as baselines are established (see Table 3-2). During testing of the HIMSS instrument, changes may be needed to correct software errors, or functional changes may be requested by project personnel. These changes will be accomplished through the software change procedures discussed in 3.4.2. Upon approval, changes will be made to the relevant documentation and the affected items will be reviewed and assigned new version identification. Acceptance testing of the revised code will be determined by the performance assurance manager. The retests will usually be in the form of reruns of the test procedures uncovering the error. If the change was performed to satisfy new requirements, the test plan and procedures will be updated and the test runs applicable to the modifications executed.

Attachment A
Hughes Aircraft Company Practice 5-0-6
Software Management/Engineering

Practice

ENGINEERING

HUGHES

*NO. 5-0-6

SUBJECT Software Management

DATE 5-31-89

SUPERSEDES Company Practice 5-0-6, "Software Engineering Management", dated 8-15-86 and Company Practice 5-0-7, "Software Engineering Practices", dated 9-30-85

REFERENCE Company Policy 5-1, "Engineering"
Company Practice 5-0-0, "Engineering and Design Management"
Company Practice 5-0-1, "Test Management"
Company Practice 5-0-2, "Design Review"
Company Practice 6-10-0, "Configuration Management"
Company Practice 19-60-00, "Software Quality Assurance"

PURPOSE To specify Company practice for the management of computer software.

APPLICABLE TO All Company organizations and programs/projects engaged in development and/or maintenance and control of computer software and software intensive firmware embedded in or directly employed in the design, production, testing, or operation of Company products. Personal software, deliverable studies, and prototype software developed during concept exploration are exempt from the requirements of this Practice.

DEFINITIONS Software - Computer programs, databases and documentation, including software requirements and design documentation, source and executable codes, and the media containing the software.

Support Software - Software directly employed in the development, production or testing of items that impact the quality of final delivered products.

Embedded Software - Software (including firmware) delivered as part of a hardware configuration item, computer software configuration item, or other product.

Firmware - The combination of a hardware device and computer instructions or computer data that reside as software on the hardware device.

Practice

ENGINEERING

HUGHES

NO. 5-0-6

SUBJECT Software Management

DATE 5-31-89

DEFINITIONS (continued)

Personal Software - Software developed and used by individuals to assist them in the conduct of their daily tasks and not subject to significant dissemination or use within the Company. Also included is commercially available software such as word processing or spreadsheet packages used on personal computers.

GENERAL

1. Computer software is essential to the function of many of the Company's products and also to the design, production and acceptance of many of these products. It is the Company's objective to acquire or produce and to control and use software at the lowest overall cost consistent with quality and functional requirements.

PRACTICE

2. Applicable sections of engineering practices, such as Company Practices 5-0-0 and 5-0-1 addressing engineering and design management, test management, configuration management, etc., are also applicable to software. Specific requirements applicable to software are described in this Practice.
3. Software contained in hardware (firmware) is subject to software controls during development. Firmware is subject to hardware controls after the software is programmed in. Firmware that is modifiable (e.g. EPROMs) is controlled as software rather than hardware.
4. Software engineering systems, practices and procedures are established and documented for guidance and control of software development. These elements are typically considered: a requirements definition process; a design and implementation process; a design review process in accordance with Company Practice 5-0-2; a corrective action system; appropriate software safety, reliability, maintainability and risk analyses; and management reporting and controls.
5. Software test and evaluation systems, practices and procedures are established and documented in accordance with Company Practice 5-0-1 to determine that requirements are met. The practices establish the independence of software testing at the qualification test level.

Practice

ENGINEERING

HUGHES

NO. 5-0-6

SUBJECT Software Management

DATE 5-31-89

PRACTICE (continued)

6. Software release and change control systems, practices and procedures are established and documented in accordance with Company Practice 6-10-0, and provide for efficient and effective change control during software design, implementation, testing and support. Procedures for assuring the integrity of working libraries and the maintenance of finished products in software repositories are defined. For embedded software the identification is related to the system, subsystem and hardware product identification requirements.
7. Software quality assurance systems, practices and procedures are established and documented in accordance with Company Practice 19-60-00 to provide for assurance and verification that software requirements and quality attributes are achieved as the result of good design practice. Engineering reviews are supplemented by software quality assurance evaluations.
8. Documentation of the processes prescribed in Paragraphs 4, 5, 6 and 7 above and their outputs is provided in sufficient detail to provide for review, management and evaluation of the processes. The software development plan is normally the top-level plan defining the overall software management/development environment and associated tailoring. For support software the plans may be in the form of approved practices, procedures, and/or instructions.

8.1 Tailoring of Standards and Plans

8.1.1 Tailoring of customer requirements and standards is documented in the contract statement of work and attachments. Such tailoring usually involves deletion/modification of specific paragraphs or sections of contractually required customer standards and data items. Contractor-suggested tailoring normally occurs during proposal and negotiation phases of a contract. Tailoring may be affected by any or all of the following: (1) end use of the software, (2) criticality, complexity or other program-unique characteristics, (3) applicable program phase, and (4) the specific objectives of the program.

8.1.2 Software management and technical plans document the tailoring of Hughes standards, procedures and instructions to meet the requirements of the program or project. The importance of each element of the development effort and its effect on the quality and cost is assessed. Multiple plans may be combined into a single software development plan for small projects.

Practice

ENGINEERING



NO. 5-0-6

SUBJECT Software Management

DATE 5-31-89

PRACTICE (continued)

9. Software developed by subcontractors under contract to the Company is subject to the requirements of this Practice. Procurement documents are reviewed to ensure the inclusion of appropriately tailored requirements.

RESPONSIBILITY

10. Major organizations provide the resources needed to establish software engineering and management practices and procedures, and conduct software engineering activities in support of their products.
11. Engineering, program management and support organizations establish and document systems to develop, test, release, control and assure the quality of software.
12. Group/division/program product quality activities assist engineering and program management in implementation of this Practice and assure compliance verification.

D. D. Donalson
Staff Vice President
Quality Management

Practice

NO. 5-0-6 /CN-1


SUBJECT: CHANGE TO 5-0-6, "Software Engineering"

Date 2-24-89

CHANGE NOTICE #1

In the REFERENCE section, change Company Practice 19-0-2, "Software Quality Assurance" to Company Practice 19-60-00. The title remains the same.

APPROVED


P.J. Hedlin, Head
SCG Directive Systems

Please file this Change Notice in front of the affected Practice in your Manual.
This change will be incorporated into the next revision of the Practice.

Practice
ENGINEERING
SPACE AND COMMUNICATIONS GROUP

No. 5-0-6

Date: 9-11-89

Subject: Software Engineering

SUPERSEDES *Group Practice 5-0-6 dated 10-15-87

AUTHORIZING DOCUMENT Company Practice 5-0-6 "Software Management"

REFERENCE Company Practice 16-0-1, "Program/Project Management"
Group Practice 5-0-0, "Engineering and Design Management"
Group Practice 5-0-1, "Test Management"
Group Practice 5-0-2, "Design Review"
Group Practice 5-0-53, "Systems Engineering"
Group Practice 6-10-0, "Configuration Management"
Group Practice 16-0-3, "Work Authorization and Delegation"
Group Practice 16-0-10, "Program Start-up Activities"
Group Practice 16-1-2, "Requirements Flowdown"
Group Practice 19-60-00, "Software Quality Assurance"
Group Manual No. 60, "Engineering Procedures"

PURPOSE To establish a consistent SCG software engineering methodology.

APPLICABLE TO All SCG organizations and programs/projects engaged in the development, modification, maintenance, or control of mission, direct support, or technical support software.

DEFINITION **COMPUTER DATA** - Machine readable information that is processed by a computer program.

CRITICAL SOFTWARE - Mission, direct support, or technical support software that the customer or management has determined to pose significant risk.

DIRECT SUPPORT SOFTWARE - Software used for qualification or acceptance of an item listed on a program master index.

EXISTING SOFTWARE - Software that has been purchased, supplied or previously developed (reusable).

MAJOR SOFTWARE EFFORT - Software development, modification, or maintenance involving two or more man-months total effort.

MASTER INDEX - An indentured list of all major components required for a program (see Engineering Procedure 11-1-50).

MINOR SOFTWARE EFFORT - Software development, modification, or maintenance involving less than two man-months total effort.

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Subject: Software Engineering

Date: 9-11-89

MISSION SOFTWARE - Software related to mission operation or mission support functions.

SOFTWARE CONFIGURATION MANAGEMENT - The management and technical effort necessary to identify, describe, control and account for changes to computer software and its associated documentation.

SOFTWARE ENGINEERING - The management and technical effort necessary to establish requirements, design, code, integrate, validate, document, and maintain computer software.

SOFTWARE QUALITY ASSURANCE - A series of planned activities carried out during all phases of the software life cycle to assure that the resulting product satisfies quality requirements.

TECHNICAL SUPPORT SOFTWARE - Software used for design, analysis, simulation, manufacture, or test (other than qualification or acceptance). Personal software as defined in Company Practice 5-0-6 is excluded.

FORMS Software Development File Cover Sheet (Form 20883 SC)

PRACTICE

1. Computer software is essential to the development, production, and operation of Group products and can itself be a Group product. General requirements applicable to software engineering efforts are defined by the following Group Practices and Engineering Procedures:
 - 1.1 Engineering and design management, test management, design review, and systems engineering activities are performed per Group Practices 5-0-0, 5-0-1, 5-0-2, and 5-0-53 respectively, and per applicable Engineering Procedures.
 - 1.2 Work authorization and delegation, program start-up activities, and requirements flowdown are performed per Group Practices 16-0-3, 16-0-10, and 16-1-2.
 - 1.3 Software Quality Assurance activities are consistent with Group Practice 19-60-00.
 - 1.4 Software configuration is managed per Group Practice 6-10-0 and Group Manual No. 60 (EP 12-9-50).

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Subject: Software Engineering

2. Specific controls required for mission, direct support, and technical support software are defined in attachments to this Practice.
 - 2.1 Control elements required for each software category are specified in Attachment A.
 - 2.2 Software documents follow the format specified in Attachment B unless contract requirements dictate otherwise.
 - 2.3 Divisions establish a software corrective action process for major mission and major direct support software development efforts as specified in Attachment C.
3. Additional software controls are defined by Divisions and Programs when necessary because of contractual requirements, complexity, criticality, or end use of the software or its supported application.
 - 3.1 Controls for critical software are defined in Division instructions, software development plans, and/or risk management plans.
 - 3.2 Controls for computer data are defined in Division instructions.
 - 3.3 When existing software is elevated to a more stringently controlled category, the need for additional controls is reviewed.

RESPONSIBILITY

4. DIVISION MANAGERS:

- 4.1 Ensure that Division instructions and standards define a disciplined approach to planning, organizing, implementing, and controlling software engineering and meet the requirements of this Practice.
- 4.2 Provide the resources, organization, training, and corrective action process needed to conduct software engineering in accordance with this Practice.
- 4.3 Ensure that internal evaluations and subcontracts reflect the requirements of this Practice.

5. PROGRAM MANAGERS:

- 5.1 Ensure that program plans, funding, schedules, and reviews reflect the requirements of this Practice.

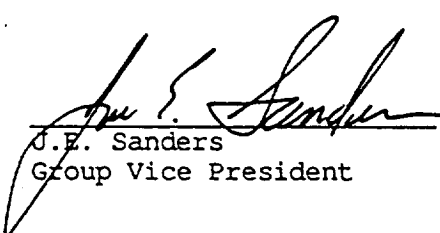
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-
- 5.2 Address critical and mission software engineering activities during the program start-up phase as defined in Group Practice 16-0-10.
 - 5.3 Ensure compliance with all customer approved software specifications, standards, and plans.
 - 5.4 Flow down contractual software engineering requirements to performing organizations per Group Practice 16-1-2.
 - 5.5 Approve software development plans for critical and mission software and track progress to the plan.
 - 6. RESPONSIBLE ENGINEERING ACTIVITIES conduct software activities in accordance with this Practice and all applicable instructions, standards, and procedures.


J.E. Sanders
Group Vice President

Practice

ENGINEERING
SPACE AND COMMUNICATIONS GROUP

No. 5-0-6
*Attachment A
Date: 9-11-89

Subject: SCG Software Requirements

CONTROL ELEMENT	DEFINED BY	MISSION			SOFTWARE CATEGORY DIRECT SUPPORT			TECHNICAL		
		Maj	Min	Ex	Maj	Min	Ex	Maj	Min	Ex
ORGANIZATION STANDARDS										
Rqmts Def, Design, Coding, Integ, Test	DIVISION	X	X							
Baselines	EP 12-2-50	X	X			X				
Identification and Marking	EP 12-9-50	X	X	X		X	X	X	X	X
Library Controls	EP 12-9-50	X	X	X		X				
PROJECT PLANS										
Development Plan (SDP)	Attach. B	X	X			X				
Test Plan (May be included in SDP)	Attach. B	X				X				
Configuration Management Plan "	DIVISION	X								
Quality Assurance Plan	GPR 19-60-00	X				X				
PROJECT DOCUMENTATION										
Requirements Spec	Attach B	X	X			X				
S/W Development File	Form 20883 SC	X	X			X	X		X	
Version Description Document	Attach. B	X	X			X				
User's Manual	Attach. B					X	X			
OTHER										
Internal Reviews	GPR 5-0-2	X				X				
Configuration Status Records	EP 12-9-50	X	X	X		X	X	X	X	
Corrective Action System	Attach. C	X				X				

- X = Control element required for this software category
- Maj = Two or more man-months effort
- Min = Less than two man-months effort
- Ex = Existing (purchased, supplied, or previously developed)

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No. 5-0-6
*Attachment B
Date: 9-11-89

Subject: Software Document Formats

This attachment defines standard section numbering and suggested section content for the following documents:

1. Software Development Plan
2. Software Development File
3. Software Requirements Specification
4. Software Design Document
5. Software Test Plan
6. Software Test Description
7. Software Test Report
8. Version Description Document
9. Software User's Manual

1. SOFTWARE DEVELOPMENT PLAN

REQUIRED FORMAT	SUGGESTED CONTENT
Title Page	Document number, revision level and date, "Software Development Plan," software name, system name, contract number, CDRL number, customer name, "Hughes Aircraft Company Space and Communications Group"
Table of Contents	Page number of each titled paragraph, figure, table, and appendix
1. Introduction	Identification and purpose of the software to be developed, purpose and summary of this plan, and its relationship to other plans
2. Software Development Management	Project organization, resources, schedule, milestones, risk management, security, organizational interfaces, subcontractor management, formal reviews, software development library, corrective action process, and problem/change report format
3. Software Engineering	Software engineering organization, resources, standards, procedures, methodology, and use of existing software
4. Testing	Testing organization, resources, approach, assumptions, and constraints; test formality; customer/QA participation; include or reference software test plan information.

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Date: 9-11-89

Subject: Software Document Formats

SOFTWARE DEVELOPMENT PLAN (Continued)

REQUIRED FORMAT	SUGGESTED CONTENT
5. Software Product Evaluations	Specification reviews, preliminary and critical design reviews, code walk-throughs, test readiness reviews; and associated organization, resources, procedures, tools, activities, and records
6. Software Configuration Management (SCM)	Configuration management organization, resources standards, and procedures; configuration identification, control, status accounting, and audits; and major configuration management milestones; reference separate SCM plan and/or program CM plan
7. Software Quality Assurance (SQA)	SQA organization, resources, procedures, tools, reviews, and records; reference separate SQA plan and/or program QA plan
8. Other Software Development Functions	Other organizations, personnel, resources, and procedures involved in the software development effort
Appendixes (A, B, etc.)	Background information, definitions, acronyms, and abbreviations

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Subject: Software Document Formats

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2. SOFTWARE DEVELOPMENT FILE (SDF)

REQUIRED FORMAT	SUGGESTED CONTENT
Cover Sheet (Form 20883 SC)	Program/project name, SDF name and number, category, custodian, routine or modules included, originator and date for each section
1. Overview	Names and purpose of routines and data blocks, originator, schedule, status, reviewed approvals and dates, revision log, and referenced documents
2. Requirements	Requirements, capabilities, constraints, interfaces, etc., that the software unit must satisfy
3. Design	Logic flow, algorithms, equations, constants, parameters, data structure and flow, interfaces, pseudo-code, program design language, processing logic trees, error handling etc.
4. Code	Current source code listings
5. Test Plan	Test approach, methods, procedures, cases, acceptance criteria, and support software
6. Test Results	Results of test runs, deviations from expected results
7. Problem Reporting	Problems encountered in the code or documentation, how problems were or will be resolved
8. Reviewer/Auditor's Comments	Comments resulting from the review of audit of this SDF
9. Notes	Deviations from approved standards, installation, usage, and any relevant notes, memos, reports, etc.

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Subject: Software Document Formats

No. 5-0-6
*Attachment B
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3. SOFTWARE REQUIREMENTS SPECIFICATION

REQUIRED FORMAT	SUGGESTED CONTENT
Title Page	Document number, revision level and date, "Software Requirements Specification," software name, system name, contract number, CDRL number, customer name, "Hughes Aircraft Company Space and Communications Group"
Table of Contents	Page number of each titled paragraph, figure, table, and appendix
1. Scope	Identification and purpose of the software to be developed, purpose and summary of this specification
2. Applicable Documents	List of standards, procedures, instructions, plans, specifications, etc. referenced in this document
3. Engineering Requirements	Software functions, internal and external interfaces, data elements, adaptation, performance, resource utilization, safety, security, design constraints, software quality factors, human engineering, and traceability to higher level requirements
4. Qualification Requirements	Qualification methods (demonstration, analysis, inspection, etc.) used to ensure that the requirements of section 3 are satisfied; verification matrix relating section 3 requirements to section 4 tests
5. Preparation for Delivery	Marking, labeling, packaging, and handling of the delivery media
6. Notes	Information that makes this specification more understandable such as background information, definitions, acronyms, and abbreviations
Appendixes (A, B, etc.)	

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ENGINEERING
SPACE AND COMMUNICATIONS GROUP

No. 5-0-6
*Attachment B
Date: 9-11-89

Subject: Software Document Formats

4. SOFTWARE DESIGN DOCUMENT

REQUIRED FORMAT	SUGGESTED CONTENT
Title Page	Document number, revision level and date, "Software Design Document," software name, system name, contract number, CDRL number, customer name, "Hughes Aircraft Company Space and Communications Group"
Table of Contents	Page number of each titled paragraph, figure, table, and appendix
1. Scope	Identification and purpose of the software that was designed, purpose and summary of this document
2. Referenced Documents	List of standards, procedures, instructions, plans, specifications, etc. referenced in this document
3. Preliminary Design	Purpose, architecture, structure, subcomponents, interfaces, states, modes, execution control flow, data flow, memory and processing time allocation, and design constraints
4. Detailed Design	Global and local data elements, interrupts, signals, algorithms, error handling, data conversion, interfaces, logic flow, data structures and files, and limitations for each software subcomponent
5. Data Elements	Name, description, units of measure, allowable values, accuracy, precision, type (integer, ASCII, etc.), format, initialization, source, and use of data elements
6. Data Files	Purpose, use, maximum size, access method, record structure and size, and data description
7. Requirements Traceability	Traceability of software subcomponents to the requirements spec. (may be shown graphically)
8. Notes	Background information, definitions, acronyms, and abbreviations
Appendixes (A, B, etc.)	

Practice
ENGINEERING
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Subject: Software Document Formats

No. 5-0-6
*Attachment B
Date: 9-11-89

5. SOFTWARE TEST PLAN

REQUIRED FORMAT	SUGGESTED CONTENT
Title Page	Document number, revision level and date, "Software Test Plan," software name, system name, contract number, CDRL number, customer name, "Hughes Aircraft Company Space and Communications Group"
Table of Contents	Page number of each titled paragraph, figure, table, and appendix
1. Scope	Identification and purpose of the software to be tested, purpose and summary of this plan. Relationship of this plan to other plans such as development QA and/or other test plans
2. Referenced Documents	List of standards, procedures, instructions, plans, specifications, etc. referenced in this plan
3. Software Test Environment	Hardware and software that supports testing; test concepts, strategies, methods, reviews, and controls
4. Test Identification	Objective, test requirements, cross reference to software requirements, type (stress, timing, erroneous input, capacity, etc.), level (CSCI, CSC, CSU), method, assumptions, constraints, data recording, schedule for each test
5. Data Recording Reduction and Analysis	Procedures used, process, analysis, documented test results, and determination whether test objectives have been met; QA participation and impounds; reporting procedures
6. Notes	Background information, definitions, acronyms, and abbreviations
Appendixes (A, B, etc.)	

Practice
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Subject: Software Document Formats

No. 5-0-6
*Attachment B
Date: 9-11-89

6. SOFTWARE TEST DESCRIPTION

REQUIRED FORMAT	SUGGESTED CONTENT
Title Page	Document number, revision level and date, "Software Test Description," software name, system name, contract number, CDRL number, customer name, "Hughes Aircraft Company Space and Communications Group"
Table of Contents	Page number of each titled paragraph, figure, table, and appendix
1. Scope	Identification and purpose of the software to be tested, purpose, and summary of this document
2. Referenced Documents	List of standards, procedures, instructions, plans, specifications, version description documents, etc. referenced in this document
3. Test Preparations	Schedule, location, briefings, equipment, block diagrams, cabling, switch settings, support software, protocols, sequence of operations, reference to standard procedures
4. Test Descriptions	Requirements traceability, assumptions, constraints, procedure, initialization, inputs expected results, suspension, restart, and evaluation criteria for each test case
5. Notes	Background information, definitions, acronyms, and abbreviations
Appendixes (A, B, etc.)	

Practice
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Subject: Software Document Formats

No. 5-0-6
*Attachment B
Date: 9-11-89

7. SOFTWARE TEST REPORT

REQUIRED FORMAT	SUGGESTED CONTENT
Title Page	Document number, revision level and date, "Software Test Report," software name, system name, contract number, CDRL number, customer name, "Hughes Aircraft Company Space and Communications Group"
Table of Contents	Page number of each titled paragraph, figure, table, and appendix
1. Scope	Identification and purpose of the software that was tested, purpose and summary of this report
2. Referenced Document	List of standards, procedures, instructions, plans, specifications, version description documents, etc. referenced in this report
3. Test Overview	Summary of date, time, location, witnesses, hardware and software configuration, preparation, performance, problems, analysis, and results for each test
4. Test Results	Detailed results, anomalies, discrepancies, and deviation from test procedure for each test case
5. Evaluation and Recommendations	Analysis of capabilities, deficiencies, limitations, constraints, performance impact, and recommendations
6. Notes	Background information, definitions, acronyms, and abbreviations
Appendixes (A, B, etc.)	

Practice
ENGINEERING
SPACE AND COMMUNICATIONS GROUP

No. 5-0-6
*Attachment B
Date: 9-11-89

Subject: Software Document Formats

8. VERSION DESCRIPTION DOCUMENT

REQUIRED FORMAT	SUGGESTED CONTENT
Title Page	Document number, revision level and date, "Version Description Document," software name, system name, contract number, CDRL number, customer name, "Hughes Aircraft Company Space and Communications Group"
Table of Contents	Page number of each titled paragraph, figure, table, and appendix
1. Scope	Identification and purpose of the software, purpose and summary of this document
2. Referenced Documents	List of standards, procedures, instructions, plans, specifications etc. referenced in this document
3. Version Description	Inventory of materials released, inventory of software subcomponents, changes installed, adaptation data, interface compatibility, documentation changes, effect of changes, installation instructions, possible problems, and known errors
4. Notes	Background information, definitions, acronyms, and abbreviations
Appendixes (A, B, etc.)	

Practice
ENGINEERING
SPACE AND COMMUNICATIONS GROUP

Subject: Software Document Formats

No. 5-0-6
*Attachment B
Date: 9-11-89

9. SOFTWARE USER'S MANUAL

REQUIRED FORMAT	SUGGESTED CONTENT
Title Page	Document number, revision level and date, "Software User's Manual," system name, contract number, CDRL number, customer name, "Hughes Aircraft Company Space and Communications Group"
Table of Contents	Page number of each titled paragraph, figure, table, and appendix
1. Scope	Identification, version, and purpose of the software; purpose and summary of this manual
2. Referenced Documents	List of standards, procedures, instructions, plans, specifications, etc. referenced in this manual
3. Execution Procedures	System resource and configuration requirements, initialization, operating sequence, inputs, outputs, termination, and restart
4. Error Messages	Identification, meaning, and action to be taken for each error message
5. Notes	Special instructions, background information, definitions, acronyms, and abbreviations
Appendixes (A, B, etc.)	

Practice
ENGINEERING
SPACE AND COMMUNICATIONS GROUP

No. 5-0-6
*Attachment C
Date: 9-11-89

Subject: Software Corrective Action Process

Divisions establish and use a corrective action process for major mission or major direct support software development efforts that meets the following requirements:

1. Software corrective action control points are established by Division, Program, or Product Line.
2. Problems detected in software activities or software products under configuration control are documented, prioritized, and categorized as one of the following:

- Requirements
- Design
- Code
- Data
- Interface
- Documentation
- Other

3. The software corrective action control point tracks and elevates problems as necessary to assure timely closure.
4. Recurring problems and adverse trends are identified and analyzed for root cause. Corrective actions are taken and evaluated to verify that systemic problems have been solved.

Attachment B
Hughes Aircraft Company Practice 6-10-0
Configuration Management



Practice

PRODUCT EFFECTIVENESS

* NO 6-10-0

SUBJECT Configuration Management

DATE 9-30-85

SUPERSEDES Company Practice 6-10-0 dated 11-19-84

REFERENCE Company Policy GM-0-2, "Product Design and Manufacturing"

PURPOSE To identify the basic elements and activities of configuration management and to establish responsibilities for their implementation.

DEFINITION Configuration - The functional and physical characteristics of an item as set forth in technical documentation and achieved in systems, equipment and/or software.

Configuration Identification - The technical documentation of an item as set forth in specifications and drawings, and documentation referenced therein.

GENERAL

1. Configuration management is a discipline in which technical and administrative direction and surveillance are applied to:
 - 1.1 Identifying and documenting the functional and physical characteristics of a system, equipment and/or software.
 - 1.2 Controlling changes to those characteristics.
 - 1.3 Recording and reporting change processing, implementation and status.

PRACTICE

2. Group configuration management systems provide for:
 - 2.1 Identifying, analyzing and overseeing implementation of customer/contract requirements for configuration management.
 - 2.2 Establishing internal configuration management operating plans and baselines.
 - 2.3 Establishing procedures for the preparation, release and maintenance of configuration identification (drawings, specifications and standards).

PAGE 1 OF 2

*Maintenance Revision



Practice

PRODUCT EFFECTIVENESS

SUBJECT Configuration Management

NO 6-10-0

DATE 9-30-85

- 2.4 Controlling and administering changes to released configuration identification and corresponding hardware/software.
 - 2.5 Defining, specifying and monitoring the implementation of interorganization task delegation, subcontractor and vendor configuration management requirements.
 - 2.6 Recording and reporting configuration status information needed to manage effectively the configuration of systems, equipment and/or software.
 - 2.7 Applying configuration verification to assure correlation between configuration identification and hardware/software.
 - 2.8 Conducting functional and physical configuration audits as required.
3. Approved methods for accomplishing configuration management functions are documented as Group practices and procedures. Such Group documentation contains sufficient procedural detail to permit definitive accomplishment of hardware and software configuration management practices specified herein, and to definitize communication interfaces between affected functional activities.

RESPONSIBILITY

4. Major Organizations (other than Industrial Electronics Group) develop or adopt configuration management systems and corresponding practices and procedures consistent with the practices specified herein.
5. Industrial Electronics Group:
 - 5.1 Develops or adopts configuration management systems and corresponding practices as appropriate to its product line and organizational needs.
 - 5.2 Implements negotiated configuration management requirements when providing products or services to other Company organizations.

W. E. Mathews
W. E. Mathews
Staff Vice President
Technical Management Planning

Practice

PRODUCT ASSURANCE
SPACE AND COMMUNICATIONS GROUP

NO. 6-10-0

SUBJECT Configuration Management

DATE 08-26-88

SUPERSEDES *SCG Practice 6-10-0 dated 12-15-86

AUTHORIZING DOCUMENT Company Practice 6-10-0, "Configuration Management"

REFERENCE Group Practice 5-0-0.1, "Engineering Procedures"
Group Manual No. 60, Engineering Procedures

PURPOSE To establish a Group configuration management system and define methods and responsibilities for accomplishing configuration management (CM) functions in compliance with Company Practice 6-10-0.

PRACTICE

1. The SCG Configuration Management System comprises the following elements:
 - 1.1 Command Media, including Company Practice 6-10-0 and this Practice, the Engineering Procedures (EPs) Manual, Division/Program Instructions, as required, and Program Plans that reflect unique Division/Contract CM requirements.
 - 1.2 Personnel in the Group Configuration Management Office (GCMO) and Program/Proposal Configuration Management Offices (PCMO) or Program Manager designees who perform PCMO functions.
 - 1.3 Configuration identification files and records.
 - 1.4 The Engineering Data Release System, which is the Group data base system for configuration identification files and records.
2. Configuration Management directives contained in the Engineering Procedures Manual establish methods for accomplishing the CM functions for deliverable hardware/software/firmware, special test equipment and associated software/firmware, tooling, and Group standards as follows:
 - 2.1 Preparation, release, and maintenance of configuration identification (drawings, specifications and standards).
 - 2.2 Controlling and administering changes to released configuration identification and corresponding hardware/software. Each program applies configuration control in a manner appropriate to the program. Configuration control includes appropriate provisions for

Practice

PRODUCT ASSURANCE
SPACE AND COMMUNICATIONS GROUP

NO. 6-10-0

SUBJECT Configuration Management

DATE 08-26-88

handling engineering changes, deviations, and waivers during manufacturing within Hughes as well as with subcontractors and vendors.

- 2.3 Recording and reporting configuration status information needed to manage effectively the configuration of systems equipment and/or software.
- 2.4 Defining, specifying and maintaining the implementation of Group, subcontractor, and vendor Configuration Management requirements.
- 2.5 Establishing and maintaining a configuration status accounting capability to record and report the information needed to manage a system, equipment, and/or software configuration effectively in accordance with contractual and Company requirements.
- 2.6 Configuration audits conducted as specified by contractual requirements, as directed by program management, and in accordance with EPs, to verify that the development of an item has been completed such that the item will perform as intended.
- 2.7 Verifying configuration to assure correlation between the as-designed and as-built configurations of the hardware and software.
3. PCMOs or equivalent identify, analyze and oversee the implementation of unique customer/contract requirements for Configuration Management. These unique requirements, including configuration management operating plans, are defined in Program Instructions.

RESPONSIBILITY

4. The Director of Engineering is responsible for implementing this Practice.
5. The GCMO within the Engineering Directorate is responsible for:
 - 5.1 Development and maintenance of the configuration management directives in the Engineering Procedures Manual.
 - 5.2 Coordination of uniform CM definitions.
 - 5.3 Providing assistance in interpretation of CM requirements.

Practice


PRODUCT ASSURANCE
SPACE AND COMMUNICATIONS GROUP

NO. 6-10-0

SUBJECT Configuration Management

DATE 08-26-88

-
6. Proposal/Program Managers are responsible for:
- 6.1 Designation of a Configuration Management Office Manager in conjunction with the GCMO manager.
 - 6.2 Ensuring the preparation of Program Instructions for Program unique CM requirements of hardware and software.
7. Program Configuration Management Office Managers or program manager designees are responsible for:
- 7.1 Planning, coordinating and administering Configuration Management operations for the program.
 - 7.2 Preparation of Configuration Management Program Instructions to assure implementation of unique customer or program CM requirements.
8. Managers of Operations Divisions are responsible for assuring compliance with Group Configuration Management requirements as tailored by contract and program requirements cited in Program Instructions.


J.E. Grant,
Vice President

Practice

PRODUCT ASSURANCE
SPACE AND COMMUNICATIONS GROUP

SUBJECT Configuration Management
Functional Activities

NO6-10-0
* Attachment A
DATE 12-15-86

1. A Functional Activity is an organization(s) that is responsible for the performance of specified functions. Functional activities are designated either major or specialized. The assignment of functional activities to organizational entities is described in a configuration management plan.
2. A major functional activity is responsible for the fulfillment of a prime task in the management, design, manufacture or support of systems/equipment and also is responsible for fulfilling certain configuration management requirements. The major functional activities are:
 - 2.1 Program Management: The activity that consists of the Program Manager, the program office, and the specialized functional activities that report to the Program Manager.
 - 2.2 Engineering: The activity that designs and develops the hardware items and computer programs of a system/equipment, including the preparation and maintenance of the related configuration identification. Performance of this function may be assigned to a manufacturing activity.
 - 2.3 Manufacturing: The activity that procures, fabricates and assembles the hardware items of a system/equipment in accordance with the released configuration identification.
 - 2.4 Product Assurance: The activity that inspects and tests, or reviews the test results of, the hardware items and computer programs of a system/equipment to assure that they conform to the configuration identification. Product Assurance includes many other activities, such as, Product Assurance Engineering, Quality, Reliability, Maintainability, System Safety, Materials and Processes, etc.
 - 2.5 Release Activity: The activity that performs the release of configuration identification and maintains records and files thereof. This is normally performed by Engineering Data Control, Document Control Center (EDC/DCC), or the Program Configuration Management Office (PCMO).
 - 2.6 Support: The activity that provisions spares; prepares technical manuals; prepares service, maintenance or modification bulletins or orders; establishes modification kit requirements and provides modification installation services; provides depot-level maintenance support; designs trainers and conducts training; and performs maintainability, field and support engineering.
 - 2.7 Contracts: The activity that administers contracts from customers.

Practice
PRODUCT ASSURANCE
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SUBJECT Configuration Management
Functional Activities

NO 6-10-0
Attachment A
DATE 12-15-86

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3. A specialized functional activity is part of, or performs tasks for, a major functional activity. Specialized functional activities within Program Management and Engineering are:
- 3.1 Program Configuration Management Office (PCMO): The PCMO plans and administers the required configuration management operations of the program. The functions of the PCMO are as follows:
- a. Plans and Instructions
 - b. Configuration Identification
 - c. Configuration Control
 - d. Configuration Status Accounting
 - e. Configuration Audits
- 3.1.1 The Engineering Change Center (ECC) under the direction of the PCMO administers and records the flow of configuration change control forms and data utilized in processing engineering changes for a program.
- 3.2 Change Review Board (CRB): The CRB reviews and acts on engineering changes for submittal to a customer or for incorporation. Membership of a CRB consists of a chairman appointed by the Program Manager and representatives from Program Management, Engineering, Manufacturing, Product Assurance, Contracts and other participating activities.
- 3.3 Responsible Engineering Activity (REA): The REA is assigned design responsibility for an item of a system/equipment. For any single item, there is only one REA.



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SUBJECT Configuration Management
Functional Activities

NO. 6-10-0
Attachment A
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- 3.4 Systems Engineering: Systems engineering is responsible for determining the functional and physical requirements of a system, providing these requirements for inclusion in appropriate configuration identification documents, and monitoring the technical integrity of the system throughout all phases of the program. Systems engineering is also responsible for assisting in the coordination of Class I and IIA engineering changes with all affected and REAs and for participating in the analysis and acceptance or rejection of these changes.
- 3.5 Engineering Data Control (EDC)/Document Control Center (DCC): EDC/DCC is assigned to the Technology Division (Div 41) and performs the release function for engineering data applicable to deliverable and non-deliverable hardware. EDC/DCC may perform the release function for engineering data applicable to deliverable software.

Attachment C
Hughes Aircraft Company Practice 19-60-00
Software Quality Assurance

Practice

QUALITY ASSURANCE
SPACE AND COMMUNICATIONS GROUP

No. 19-60-00

Subject: Software Quality Assurance

Date: 10-5-89

* SUPERSEDES Group Practice 19-60-00 dated 8-26-88
 Group Quality Assurance Procedure 19-60-00 dated 12-19-88

AUTHORIZING Company Practice 19-60-00, "Software Quality Assurance"
DOCUMENT

REFERENCE Company Practice 19-12-00, "Quality Planning"
 Group Practice 5-0-6, "Software Engineering"
 Group Practice 19-10-00, "Product Assurance"
 Group Practice 19-10-15, "Corrective Action Boards"
 Group Engineering Procedure 12-9-50, "Software Configuration
 Management"
 Group Quality Assurance Procedure 19-12-00, "Quality
 Planning"

PURPOSE To define SCG Software Quality Assurance (SQA) requirements.

APPLICABLE TO All SCG Performing Organizations engaged in the development,
 operation, and maintenance of computer software/firmware
 embedded or directly employed in the design, production,
 testing, or operation of SCG products.

DEFINITION CERTIFICATION - A process, which may be incremental, where
 objective evidence is generated which demonstrates that an
 item satisfies specified requirements.

 FIRMWARE - The combination of a hardware device and computer
 instructions or data that reside as software on the hardware
 device.

 SOFTWARE - Computer programs, data, and documentation
 required to enable computer hardware to perform
 computational, data manipulation, or control functions.

 SOFTWARE DOCUMENTATION - The specifications, procedures,
 test reports, source code, etc., created to specify,
 describe, and/or plan events, requirements, processes, and
 products.

 SOFTWARE LIFE-CYCLE PROCESS - Those identifiable software
 phases, from initial requirements specification through the
 various design, development, installation, operation, and
 maintenance phases.

 SOFTWARE QUALITY - The ability of a software product to
 satisfy its applicable standards and requirements.

Practice

QUALITY ASSURANCE
SPACE AND COMMUNICATIONS GROUP

No. 19-60-00

Subject: Software Quality Assurance

Date: 10-5-89

SOFTWARE QUALITY ASSURANCE (SQA) - A series of planned activities carried out during all phases of the software life cycle to assure that the resulting product satisfies quality requirements.

SOFTWARE QUALITY EVALUATION - A formal, documented assessment of programs/projects to determine the adequacy of the software development process and conformance to Company and contract requirements.

VERIFICATION - In-process confirmation that products of a given phase of the development cycle fulfill the requirements of the previous phase.

GENERAL

1. Software Quality is achieved by the application of standards, controls, methodologies, reviews, evaluations, and tests during requirements analysis, top and detail-level design, coding, testing, integration, qualification, operational implementation, and final product maintenance.
2. Software Quality Assurance resides within the Quality Assurance organizations and is therefore independent of organizational elements that directly perform software development. Quality Assurance practice governs SQA practice to the extent that it is applicable.
3. This Practice is to be used in conjunction with Group Practice 5-0-6 and Engineering Procedure 12-9-50.

PRACTICE

4. Software QA Program Planning encompasses the SQA functions defined in the following paragraphs, as well as those software engineering controls required by Group Practice 5-0-6.
5. Software quality tools, methodologies, and techniques are applied to monitor, evaluate, and adequately document quality aspects of the software.
6. Software Documentation is reviewed for adherence to engineering requirements from a quality perspective.

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7. The Software Configuration Management and Library Controls process is reviewed for compliance to Engineering Procedure 12-9-50 and contractual requirements. SQA participates in the software configuration management process per organizational and/or contractual requirements.
 8. Software Test/Qualification: Test plans, procedures, instructions, and the subsequent testing process itself are reviewed, as applicable, for compliance with Company and contractual software quality requirements.
 9. A SQA "Periodic Review and Evaluation Program" is conducted to assure adherence to Company, SCG, organizational, and contractual software quality requirements.
 10. Software Quality Records are maintained as objective evidence and to provide a traceability trail of SQA activities.
 11. Product/Process Verification, Certification, and Delivery: Where required, SQA verifies that qualification requirements of a contract, project, or product phase have been performed in accordance with the previous phase's specification(s). If required, certification of the verification process is demonstrated via approved documented objective evidence. SQA also assures that procedures are correctly applied to the verified product in terms of storage, handling, packaging, marking, and delivery, in order to prevent damage, loss, deterioration, degradation, or substitution of the product.
 12. Software Subcontractor Surveillance: SQA assures that applicable software quality requirements are flowed down to subcontractors. SQA reviews and evaluates subcontractor software plans, processes, and products for compliance with subcontract requirements. Corrective action/reporting program(s) are implemented per organizational and/or contractual requirements.
 13. A Software Corrective Action and Trend Analysis Program is implemented to span the breadth of the Software Life-Cycle Process. Major Corrective Action Program elements themselves are further defined by Group Practice 5-0-6, Attachment C, "Software Corrective Action Process."
 - 13.1 Corrective Action findings/concerns are documented and processed as objective evidence of software quality reviews and evaluations. Records of assigned corrective action requests are maintained, monitored, and reported upon. Follow-up activities are pursued to assure effective and timely closeout of corrective action items.

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- 13.2 Trend Analysis - Maintained corrective action data are periodically reviewed and analyzed for adverse trends. Adverse trends identified are brought to the attention of management for appropriate action.

RESPONSIBILITY

14. THE DIRECTOR OF PRODUCT ASSURANCE is responsible for:

- 14.1 Implementation of this Practice at the Group level.
- 14.2 Development of Group Software Quality Procedures, Instructions, and plans, as required to implement this Practice at the Group level.
- 14.3 Review, with disapproval authority, of Performing Organizations Software Quality command media for compliance with Company and Group quality requirements.
- 14.4 Performing reviews and evaluations of the SQA activities of Divisions, of Directorates, and Programs to assure compliance with this Practice and/or other SCG software command media and quality plans.

15. PERFORMING ORGANIZATION MANAGERS are responsible for:

- 15.1 Compliance with Company and Group Quality Practices and contractual quality requirements.
- 15.2 Developing software quality command media and program plans as required to implement this Practice.
- 15.3 Implementing a software quality assurance program in their respective organizations that complies with the requirements of this Practice and program SQA plans as developed.
- 15.4 Staffing the organization's SQA program function with the personnel necessary to assure adherence to this Practice and contractual requirements.

16. PROGRAM MANAGERS are responsible for:

- 16.1 Ensuring software quality requirements flow down from contract to Performing Organizations.

Practice

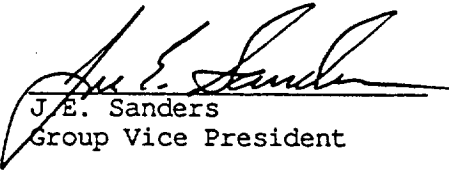
QUALITY ASSURANCE
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- 16.2 Preparation of Program SQA Plans in accordance with those requirements as defined in Attachment A, Group Practice 5-0-6, "SCG Software Requirements."
- 16.3 Ensuring funding for implementation and support of approved Program SQA activities.


J. E. Sanders
Group Vice President

4.5 CONTAMINATION PLAN

HUGHES

Space and Communications Group

GOVERNMENT ELECTRONICS SYSTEMS DIVISION

HS256C-1045-0058

CONTAMINATION PLAN

**FOR THE
HIGH RESOLUTION MICROWAVE
SPECTROMETER SOUNDER
(HIMSS)
INSTRUMENT PROGRAM**

**AN INSTRUMENT FOR NASA'S
EARTH OBSERVING SYSTEM**

PRELIMINARY

OCTOBER 1990

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1. INTRODUCTION

The HIMSS Contamination Control Plan describes in detail the general requirements and disciplines necessary to achieve a Class 100,000 clean room environment. All hardware on the HIMSS program will be fabricated, assembled, and tested in accordance with HP 10-22, Requirements for Controlled Areas.

The definition of a clean environment, in accordance with Federal Standard 209 as required by GSFC S-480-18, is defined in 3.1.

The contents of this plan are disseminated to all affected personnel by the Program Instruction TBD at the direction of the program manager.

2. APPLICABLE DOCUMENTS

The documents listed form a part of this plan to the extent described and with the exception and modifications noted within the plan.

Federal

Federal Standard 209	Clean Room and Work Station Requirements, Controlled Environment
BB-N-411	Nitrogen, Technical
Federal Standard-TTI-753	Alcohol, Isopropyl

Military

MIL-D-3464	Desiccants, Activated, Bagged, Packing Use and Static Dehumidification
------------	--

Hughes

MEI 1.12.1G	Clean Room and Environmental Control Area
HP 10-22	Requirements for Controlled Areas
Program Instruction TBD	Area Environmental Control
Program Instruction TBD	Outgassing and Contamination Control

3. CLEAN ROOM CLEANLINESS REQUIREMENTS

3.1 Environment

Airborne particles will not exceed a total of 100,000 particles of 0.5 micron and larger with no more than 700 particles of 5.0 microns and larger per cubic foot. The temperature will be controlled to 75° ±10°F with the relative humidity controlled to 65 percent.

3.2 Out of Control Condition

If airborne particle count, temperature, humidity, or airflow extend beyond the limits specified herein, Maintenance shall be immediately informed that an emergency exists and prompt action is mandatory. All sensor activities can be suspended at the direction of the Sensor Manager until the out of control condition has been corrected.

3.3 Material Removal Operations

Operations such as sanding, buffing, drilling, grinding, filing, etc., may be performed provided that the work is isolated by a dust hood or RCAS 2400 anti-static nylon shielding which will prevent the airborne count from exceeding the limits specified in 3.1. If it is absolutely necessary to conduct such operations on a component or system during assembly, repair, or retrofit, then the area shall be isolated from any flight hardware (including instruments) with an RCAS 2400 anti-static nylon enclosure. A vacuum fixture shall be used to remove debris at the source.

3.4 Heating Operations

Heating operations such as soldering, desoldering, hot knife cutting, etc., which result in the production of vapors, shall be permitted provided that such operations do not cause the airborne particle count to exceed the limits specified in 3.1. Such operations shall be prohibited within 20 feet of any thermal control finished surfaces and/or optical surfaces unless such surfaces are completely wrapped or bagged with RCAS 2400 anti-static nylon. A vacuum fixture shall be used to remove vapors at the source.

3.5 Writing Instruments

Ball-point (metal ball) pens shall be the only writing instruments permitted in environmentally controlled areas. Fountain pens, lead pencils, erasers, crayons, chalk, and grease pencils are specifically prohibited.

3.6 Paper

No notebooks, manuals, or paper products with the exception of standard writing paper shall be permitted in clean areas.

3.7 Waste Containers

Only closed top waste containers are permitted in environmentally controlled areas. Containers shall be made of plastic or noncorroding metal with an epoxy finish and shall be lined with disposable plastic bags that can be securely closed at the top prior to removal from the area. The dumping of waste containers within environmentally controlled areas shall not be permitted.

3.8 Garments

Mandatory garments are garments which have been designated by the Program Office for use only in the clean room. Any garment that is visibly soiled shall be replaced with a clean one, and the soiled garment shall be deposited in the container for soiled garments. Mandatory garments shall not be worn outside of the cleanroom or tent. All changing of garments shall be made in the anteroom. They shall be put on just before entering the clean area and removed immediately after exiting the clean area. Further restrictions on garments are as follows:

- 1) Shoes shall be brushed each time after having been outside of class 100,000 high bay area (e.g., each morning, after lunch, etc.) prior to stepping onto tac mat.
- 2) Gloves used in the clean room shall not be used outside the clean room area. Gloves shall be used when handling sensitive surfaces such as thermal and reflector surfaces as defined by the HIMSS Program Instruction.
- 3) In cases where mandatory garments are not available, a clean, packaged, white, antistatic smock of 65 percent dacron and 35 percent cotton may be substituted until a proper garment can be provided.
- 4) Smocks shall be snapped fully closed and sleeve cuffs snapped tightly to constrain fiber particles from clothing.
- 5) Personal articles shall not be carried into the clean area.

3.9 Hardware and Equipment Cleaning Upon Entry Into Clean Room or Tent

All hardware, support equipment, fixtures, tools, boxes, etc., shall be cleaned outside the clean room but inside the 100,000 area by thoroughly wiping (using Texwipes) with isopropyl alcohol (Federal Standard-TTI-753) and then thoroughly vacuumed. Personnel shall wear clean gloves when performing these operations.

3.10 Manufacturing Responsibilities for Cleaning Room, Support Equipment, Fixtures and Tools

The manufacturing crew chief (for each shift) shall assure that the tops (any horizontal surface) of all hardware, work benches, and support fixtures are vacuumed or wiped once each day. In addition, after any work operation has been performed, all areas in the immediate vicinity of the work area shall be vacuumed or wet mopped.

The manufacturing crew chief shall ensure that all tools, tool boxes, fixtures, etc., are vacuumed or wiped clean with alcohol in accordance with MEI 1.12.1.

3.11 Criteria for Hardware Cleanliness

Hughes Quality Assurance will perform a visual inspection in the clean room and tent at the start of each shift. Hardware and support fixtures shall be checked on a random sample basis at the discretion of the Quality Assurance representative. Any visual evidence of dust or dirt will require a vacuum cleaning of the applicable article.

3.12 Drilling, Soldering, Bonding Operations in Clean Room or Tent

When drilling, soldering, or bonding in the clean room or tent, the following procedures apply:

- 1) Drape the adjacent areas to prevent particles from dropping or floating into the work areas.
- 2) Use a vacuum hose downstream (but close) when drilling.
- 3) After the work has been completed, but before removing drape, vacuum to remove all particles from the work area and draped areas.
- 4) Remove drape and vacuum any adjacent area where particles could have floated in spite of the drape.

If contaminants other than lint may have been deposited on the hardware, clean using Texwipes and isopropyl alcohol and vacuum to remove lint deposited by the Texwipe material.

3.13 Maintenance Requirements

3.13.1 Cleaning Materials and Equipment

Materials and equipment for cleaning shall be as follows:

- 1) Sponges - Cellulose, nylon, polyurethane, or other nonshedding plastic
- 2) Mops - Cellulose, nylon, polyurethane, or other nonshedding plastic
- 3) Cloths - Approved, lint-free cloth
- 4) Pails - Plastic, stainless steel, nickel plated, or other noncorrodable material
- 5) Ladders - Anodized aluminum or wooden ladders coated with high integrity epoxy or polyurethane coatings, approved by the Materials Technology department
- 6) Floor wax - No floor wax or other temporary floor coatings shall be used in clean areas
- 7) Detergent - Only an approved commercial liquid detergent, such as Joy, shall be used. The use of bar and powdered soaps and detergents for facility maintenance or personnel cleanup shall be specifically prohibited.

3.13.2 Maintenance Cleaning Schedule

Class 10,000 clean areas shall be cleaned as specified in Table 1. Where possible, cleaning shall be accomplished during nonwork periods and with all components and instruments completely covered.

3.13.3 Environmental Monitoring

Environmental conditions such as temperature, humidity, airborne particle count, and air velocity shall be monitored at intervals specified below. Results shall be recorded in the permanent log in each area. The activity with administrative responsibility over the respective areas shall develop permanent logs of required monitoring operations. Up to date records shall be maintained and be available for review by the cognizant Quality Assurance organization.

3.13.4 Airborne Particle Count

ASTM methods that employ light scattering principles shall be used for monitoring airborne particle count. Numbers of particles per cubic foot of air shall be monitored in at least two ranges: 0.5 microns and larger and 5.0 microns and larger.

Table I. Maintenance Schedule Class 10,000 Clean Areas

<u>Areas</u>	<u>Method</u>	<u>Frequency</u>
All floor areas	Wet mop and vacuum	Daily
Fiber floor mat	Vacuum	Daily
Gelatin foot mat	Alcohol wipe	Daily
Disposable tack mat	Remove top sheet	Daily
Support area		
Beneath benches	Vacuum	Daily
Benches and cabinets	Vacuum clean and wipe	Daily
Windows	Wipe	Weekly
Walls below 8 ft	Wash	Weekly
Walls and fixture, above 8 ft	Wipe or vacuum	Monthly

3.13.5 Sampling Intervals

Samples shall be taken at TBD hour production operation intervals until four consecutive samplings are within specification limits. Once this confidence is established, samples shall be taken at a minimum of TBD hour production interval.

3.13.6 Sampling Locations

The following schedule shall be used in determining the minimum number of sampling locations within an environmentally controlled area:

<u>Room Area, ft²</u>	<u>Sampling Locations</u>
Up to 100	1
101 to 1000	2
1001 to 2500	3
2500 to 5000	4

3.13.7 Sample Counts

Sample counts from an area under evaluation shall be averaged and the value of this average shall be used to determine the level of the area. If no individual sample exceeds the desired level value by more than 20 percent and if the average is less than the desired value, the area can be considered within specification. If any one sample exceeds the desired value by more than 20 percent or if the average is more than the desired value, action shall be taken to remedy the condition.

3.13.8 Temperature and Humidity

Temperature and humidity shall be continuously monitored with a recording device.

3.14 Purging

The purging of the BAPTA per 3.17.1.2 shall take place in a nitrogen purge environment. That environment shall meet a TBD ft³/hour flow rate (filtered to 0.5 micron or less). The nitrogen shall conform to BB-N-411 Type I, Class I, Grade A.

3.15 Foreign Materials

At no time will the sensor be exposed to equipment that produces oil, hydrocarbon, or aerosol vapors.

Polyvinyl chloride polymers or other similar plastic materials shall not be used for handling, testing, or storing sensor components.

3.16 Vacuum Conditions

The chamber used for vacuum testing will contain oilless cryo high vacuum pumps. All materials and components used as test fixtures as well as the spacecraft and flight support equipment will meet flight outgassing specifications. During the vacuum test the chamber will be instrumented with cold fingers, witness mirrors, quartz crystal microbalance (QCM), and residual gas analyzer (RGA) such that condensibles and contaminants can be measured and identified. Back filling of the chamber will be with clean, dry nitrogen during the vacuum tests.

3.17 Bearing and Power Transfer Assembly (BAPTA)

This section specifies the requirements for ambient atmospheric control, internal and external to the BAPTA.

3.17.1 Requirements

3.17.1.1 Atmospheric Hazards. Common contamination materials and their deleterious effects are briefly listed. These can be harmful to the BAPTA in concentrations far below those detectable to the human senses.

- 1) Particulate - Airborne dust is composed of silica, oxides, ash, rubber, metals, and fibers. Soft material > 200 microns can increase friction by clogging working clearances and ball bearings.
- 2) Chemical - Vapors or minute particles of acid or base forming compounds (SO_2 , CaCl_2 , CO_2 , smog) and process reagents, inspection dye, and cleaning fluids can cause corrosion of metals, breakdown of insulation, and might react unfavorably with the lubricant.
- 2) Water Vapor - Water vapor will act as a catalyst to oxidize metals at 60 to 70 percent relative humidity; but when chemical contaminants are present, corrosion can occur down to 50 percent relative humidity.
- 3) Desiccant - All desiccants used will be per MIL-D-3464, Type II. Desiccant produces dust; therefore, it will never be in the same bag with or in contact with the hardware.

3.17.1.2 Controls. The following procedures shall be used on the BAPTA to control atmospheric hazards at all time, from the beginning of assembly through launch. In the event of inadvertent exposure of the BAPTA to conditions exceeding those specified herein, an emergency inspection of the BAPTA may be performed by the REA to determine whether any corrective action is required.

- 1) Clean Room Environment - Assembly and disassembly of the BAPTA shall be accomplished in a clean room area conforming to FED-STD-209, Class 10,000, 75 \pm 10°F, 50 percent maximum RH or better environment.
- 2) Controlled Environments - If the BAPTA is in a Class II controlled area per Hughes Specification HP 10-22, one of the following conditions must apply:
 - a) The BAPTA shall be continuously purged per 3.17.2 during operation only. No purge is required if the BAPTA is not in operation.

- b) The BAPTA shall be hermetically sealed in a polyethylene bag that has been purged just before sealing with dry nitrogen per BB-N-411, Type I, Class I, Grade A. It shall then be placed in a second purged bag and hermetically sealed.
- c) If humidity is controlled to less than 50 percent, then the BAPTA may be handled or operated (without purging) with a line of sight cover over the shaft to housing seals to prevent entry of dust and other particulate matter.

Transfer of the BAPTA from one condition to another shall be accomplished as rapidly as possible (never exceeding 15 minutes).

- 3) Noncontrolled Environments - If the BAPTA is not in either of the environments mentioned above, one of the following conditions must apply:
 - a) The BAPTA shall be continuously purged per 3.17.2.
 - b) The BAPTA shall be hermetically sealed in a polyethylene bag that has been purged just before sealing with dry nitrogen per BB-N-411, Type I, Class I, Grade A. It shall then be placed in a second purged bag and hermetically sealed.
 - c) The BAPTA may be operated for brief periods (less than 4 hours) in a noncontrolled area without purge provided the humidity is less than 50 percent and line of sight covers are used over labyrinth seals to prevent entry of dust and other particulate matter.
- 4) Storage (1 month or more) - The BAPTA shall be hermetically sealed in a polyethylene bag that has been purged before sealing with dry nitrogen per BB-N-411, Type I, Class I, Grade A. It shall then be placed in a purged second bag and hermetically sealed. The double sealed BAPTA shall be placed in a sealed container together with at least 24 units of desiccant. Humidity indicators on the container shall be visible from outside; if pink in color, the desiccant shall be replaced. Supports and isolation padding shall be provided in the container to eliminate the possibility of physical damage.

3.17.2 Purging Procedure

3.17.2.1 Purging Requirements. The BAPTA shall be continuously purged internally through a 0.45 micron filter with not less than $1.0 \text{ in}^3/\text{sec}$ ($2.08 \text{ ft}^3\text{-hr}$) of gaseous nitrogen that meets the requirements of Federal Specification BB-N-411, Type I, Class I, Grade A. During purging, flow rate shall be verified each time a gas bottle is changed. If unattended purging is required, gas supply shall be sufficient for that period.

Experience indicates that if contamination in the nitrogen purge line downstream from the 0.45 micron absolute filter does not exceed the following values, satisfactory despin bearing operation will occur and the in-orbit mission lifetime will be obtained.

Analysis of the nitrogen contaminants at the purge line outlet shall not exceed the following values:

Dew Point	-85°F
Hydrocarbons	3 ppm
Particle count	5 to 10 microns, 10/standard ft ³ 10 to 25 microns, 4/standard ft ³ 25 to 50 microns, 2/standard ft ³ >50 microns, 0/standard ft ³

Commercial grade nitrogen is acceptable as a source provided that the above analysis is met.

3.17.2.2 Purging Equipment. The system is shown schematically in Figure 1. The tanks may be replaced by a continuous N₂ source that meets analysis requirements. Analysis of nitrogen shall be made before initial use of the system and monthly thereafter. A data log card indicating dewpoint, hydrocarbon count, and particulate analysis shall be maintained and attached to the system at all times.

3.17.3 Design Requirements. Figure 2 shows a cross section of the BAPTA. The intricate labyrinth path shown dotted is the path the lubricant vapor follows to escape from the bearing reservoir. The design specifications is that not more than 5% of lubricant should escape over a 10 year BAPTA life. Considering the amount of lubricant present at beginning of life, the 5% escaping is also a small amount.

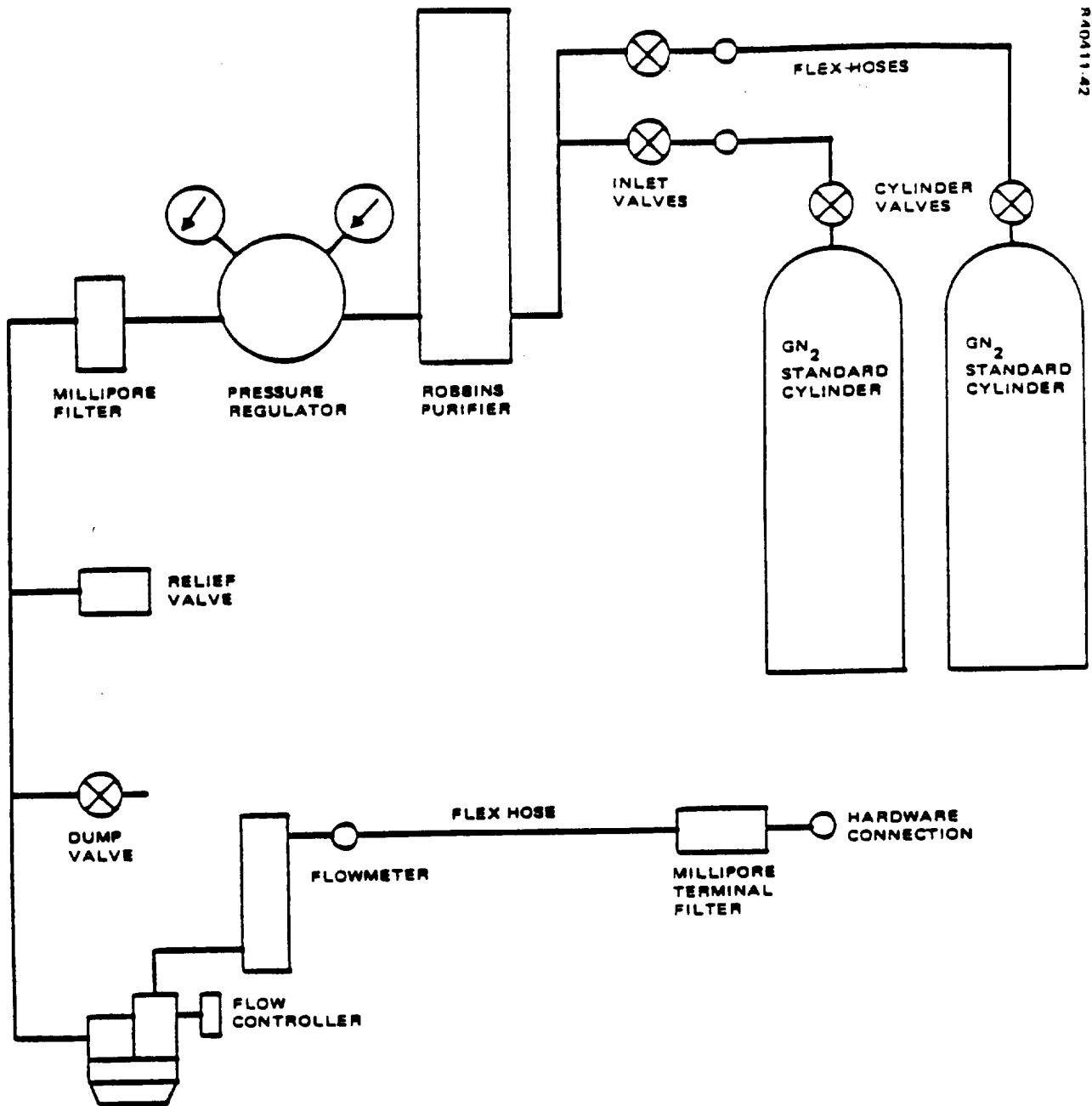
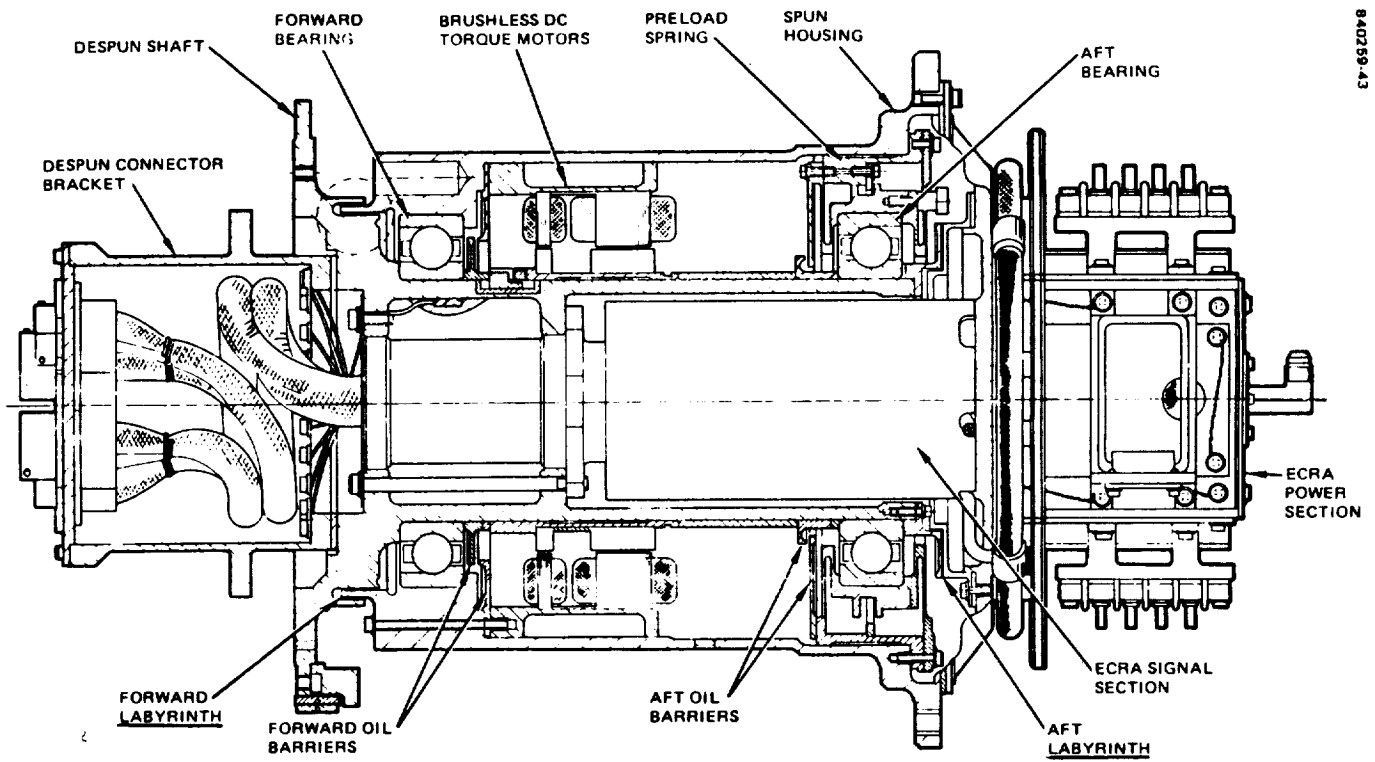


FIGURE 1. PURGING SYSTEM SCHEMATIC

3.18 Thermal Blankets. TBS.

3.18.1 Requirements. TBS.

3.18.2 Outgassing Procedures. TBS.



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3.19 General Material Requirements.

Outgassing is a major consideration in material selection. The material selected must meet the criteria of JSC 08962 (TBR) and JSC-SP-R-0022A (TBR) which limits the total weight loss to 1 percent and volatile condensible material to 0.1 percent.

4. INTEGRATION AND TEST AT EOS PAYLOAD INTEGRATION FACILITY

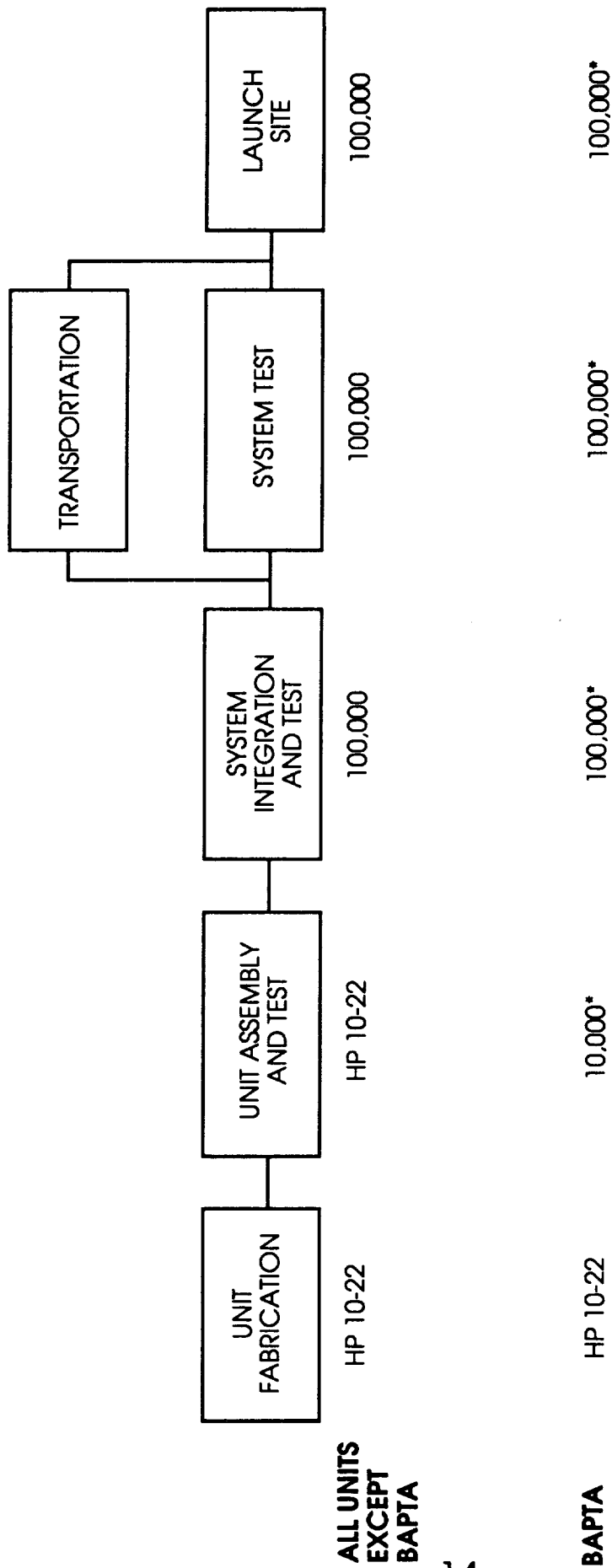
BAPTA shall be maintained in an environment per 3.17.1.2.

5. LAUNCH SITE AND LAUNCH OPERATIONS CLEANLINESS PRACTICES

TBS.

6. SUMMARY.

In summary, the sensor integration and test effort can be accomplished while maintaining an acceptable cleanliness state. The cleanliness requirements for equipment and spacecraft are summarized in Figure 3.



* 10,000 WHEN OPERATING OR SEE 3.1.17

FIGURE 3. SUMMARY OF CLEANLINESS REQUIREMENTS

ATTACHMENT 1

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1.0 GENERAL

1.1 Scope

1.1.1 This MEI provides instructions, in compliance with FED-STD-209 and HP 10-22, for SCG Clean Rooms and Controlled Areas.

1.2 Definitions

1.2.1 Controlled Areas: Areas in which particulate contamination, temperature, and humidity are controlled to a higher degree than in conventionally air conditioned industrial areas, but to a lesser degree than in Clean Rooms. Controlled Areas are designated per HP 10-22, Class I and Class II.

1.2.2 Clean Rooms: Enclosed areas in which airborne particles, temperature, pressure, and humidity are controlled to meet the requirements of FED-STD-209. Class 10,000 and Class 100,000 areas, laminar flow tunnels, and laminar flow benches are included under the category of Clean Rooms.

1.2.3 Debris: Any foreign substance or particle whose nature and presence is detectable by the unaided eye, in or on, any level of equipment from subassembly through final spacecraft assembly and test. Examples are tools, loose fasteners, wire and insulation clippings, loose solder balls, machining particles, orange sticks, and loose processing residues.

1.2.4 Micron (Micrometer): A unit of measurement equal to one millionth of a meter or 0.00003937 inch (e.g., 25 microns are approximately 0.001 inch).

1.2.5 Sensitive Surface: Any surface or item whose function could be impaired or easily damaged with contamination from fingers or skin. Some examples are thermal, optical, adhesive, electrical, or bearing surfaces.

- 2.0 PROCEDURES
- 2.1 Specific Controls
- 2.1.1 Debris Control

Debris control involves protection of flight hardware, subassemblies, and spacecraft from damage or impaired function caused by the presence of debris or foreign objects during manufacture, assembly, test, handling, repair, refitting, storage, transportation, and operation. Debris control is obtained by all personnel in functional areas following general good housekeeping rules.

- 2.1.2 Particle Control

- 2.1.2.1 The airborne particulate requirements for environmentally controlled work areas shall conform to those specified in HP 10-22 and FED-STD-209 as shown in Table 1. Particle count is based on the maximum allowable number of airborne contaminants of size 0.5 microns or larger per cubic foot of air.

Table 1. Area Designations

Class	Particle and Debris Requirements
10,000	Maximum 10,000 particles/ft ³ , 0.5 microns and larger or 65 particles/ft ³ , 5.0 microns and larger.
100,000	Maximum 100,000 particles/ft ³ , 0.5 microns and larger or 700 particles/ft ³ , 5.0 microns and larger.
I	Maximum 1500 particles/ft ³ , 5.0 microns and larger.
II	Debris control. No particulate requirements.
Grade	Temperature Requirements
A	70° - 74°F
B	67° - 77°F
C	65° - 85°F
D	No temperature requirements
Level	Relative Humidity Requirements
1	30 - 45% relative humidity
2	50% maximum relative humidity
3	65% maximum relative humidity
4	No relative humidity requirements

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2.1.2.2 Use a Royco Particle Counter or approved equivalent to determine the particle count in the immediate proximity of hardware during periods of normal occupancy and work activity.

2.1.2.3 CAUTION: Any tents (for local cleanliness control), equipment covers, and curtains (used for temporary construction areas) made of plastic film may build up static charges. Check for static before and during use to help prevent static damage to electronic hardware.

A Controlled Area of stricter classification may be located within, or adjacent to, an area of lesser classification, provided that the normal operation of the lesser class area does not degrade the cleanliness of the stricter class area.

2.1.3 Temperature Control

2.1.3.1 Temperature control is established by product integrity, process variables, operational requirements, and/or in consideration of personnel comfort. A permanent log shall be maintained for one year per 2.1.5.

2.1.3.2 Controlled Area temperatures are specified by grades as given in Table 1. Other more stringent Controlled Area temperature requirements may be directly specified, as necessary.

2.1.3.3 Clean Room temperature requirements are directly specified, as posted.

2.1.4 Relative Humidity Control

2.1.4.1 Relative humidity is established by product integrity, process variables, operational requirements, and/or in consideration of personnel comfort. A permanent log shall be maintained for one year per 2.1.5.

2.1.4.2 Controlled Area relative humidity requirements are specified by levels as given in Table 1. Other more stringent Controlled Area relative humidity requirements may be directly specified, as required.

2.1.4.3 Clean Room relative humidity requirements are directly specified as posted.

2.1.4.4 When handling static sensitive devices, observe relative humidity requirements of MEI 1.12.4.

2.1.5 Document Control

2.1.5.1 A permanent log of environmental controls, recording temperature, humidity, and airborne particle count, as applicable, shall be maintained for each Controlled Area and Clean Room, except Class II, Grade D, Level 4. The log may be in the form of dated recorder charts.

2.2 General Controls
2.2.1 Identification of Environmentally Controlled Work Areas

2.2.1.1 Each entrance to a Controlled Area or a Clean Room is posted with information indicating the level of cleanliness. A sample posting is shown in Figure 1.

2.2.1.2 Personnel entering environmentally controlled work areas shall follow the operational procedures as posted outside the entrance. Personnel shall be indoctrinated in the proper environmental procedures required for the area per 3.1.

CLEAN ROOM

1/2" letters

REQUIREMENTS PER FED-STD 209

CLASS 10,000

TEMPERATURE 72±5°F

RELATIVE HUMIDITY 60% OR LESS

AUTHORIZED PERSONNEL ONLY

SMOCKS, HOODS, AND BEARD COVERS REQ'D

3/8" letters

CONTROLLED AREA

1/2" letters

REQUIREMENTS PER HP 10-22

CLASS **II** GRADE **B** LEVEL **3**

AUTHORIZED PERSONNEL ONLY

SMOCKS REQUIRED

NO SMOKING, EATING, OR DRINKING

3/8" letters

Figure 1. Examples of Work Area Signs

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2.3 Personnel Controls

2.3.1 Protective Garments Regulated by Class

2.3.1.1 Table 2 lists protective garments required for each class of Controlled Area or Clean Room.

Table 2. Protective Garments

Class	Garment Requirements
10,000	Smocks or coveralls. Caps or hoods, cloth fabric or disposable, lint-free Clean Room grade cap.** Gloves, when handling sensitive surfaces. Beard covers. Boot or shoe covers (shoe cleaner must be used).***
100,000	Smocks or coveralls. Caps and beard covers, lint-free Clean Room grade disposable or cloth fabric.** Gloves, when handling sensitive surfaces. Shoe covers (shoe cleaner must be used).***
I	Smocks.* Caps and beard covers, disposable or cloth fabric. Gloves, when handling sensitive surfaces.
II	Smocks.* Caps and beard covers.*** Gloves.***

*Disposable type garments may be used in Controlled Areas where inherently "dirty" operations such as painting, bonding, and potting are performed.

**If individual has long hair that cannot be covered with a cap, then a hood must be used in place of a cap.

***Requirement shall be established by specific program directives.

2.3.2 Restricted General Items

2.3.2.1 The following are examples of items that are not to be brought into Controlled Areas or Clean Rooms:

- a. Easily sheddable paper, such as newspaper and cardboard boxes, except in Controlled Areas to transfer items to metal or plastic container.
- b. Chipped, torn, or broken containers.
- c. Dirty tools (those covered with chips and other debris).
- d. Unpainted and/or untreated wood - admitted in Controlled Area for 24-hour maximum.
- e. Contaminated, dirty containers of any type.
- f. Generally, any debris-contributing articles.

2.3.3 Restricted Personnel Items

2.3.3.1 Personal contaminants are controlled by keeping hands, hair, and body garments clean, and not bringing in other contaminants such as:

- a. Dirty shoes and clothing
- b. Food and drink
- c. Tobacco
- d. Graphite pencils and erasers
- e. Dirty smocks and gloves

2.3.3.2 Fab-U-Cream and Conco #212, supplied by HAC, are approved for use in environmentally controlled work areas. They are not to be stored or applied in Clean Rooms.

2.3.3.3 Prior to entering environmentally controlled work areas personnel will remove outer garments such as jackets, sweaters, and coats, and leave them in the area provided. Clothing which tends to produce lint, such as course wools, angora, and synthetic fur-blend materials will not be worn in work areas.

2.3.3.4 The following materials shall not be used (applied, administered, or removed from a container) in Controlled Areas:

- a. Drugs - pills, ointments, drops, liquids, inhalents. Closed containers may be brought into Class I and II areas only.
- b. Nail treatments - cuticle treatments, nail polish, polish remover, buffing creams or powders, artificial nail material.
- c. Food and food-like items - chewing gum, cough drops, mints and hard candies.
- d. Toiletries - cosmetics, perfumes, colognes.

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2.3.4

Temporary Employee Restrictions.

2.3.4.1

Personnel with colds, asthma, or hayfever which result in temporary periods of excessive coughing and sneezing shall be temporarily prohibited from entering Clean Rooms. The same restriction applies to personnel with temporary skin conditions, such as sunburn, which result in excessive skin shedding. Personnel with administrative responsibility over the Clean Room shall be responsible for enforcing these restrictions.

2.3.4.2

If a work area is not considered a Controlled Area or Clean Room, the responsible area management may selectively impose departmentally controlled requirements and restrictions necessary or convenient for the activities involved. This is normally covered through Departmental Instructions or Program Instructions.

2.4

Maintenance

2.4.1

The area supervisor is responsible for a maintenance schedule, of a format similar to that shown in Figure 2 and Figure 3, covering requirements for that specific area. Quality Assurance shall verify compliance to the schedule. Manufacturing shall retain the completed schedules in the area for 12 months, minimum.

2.4.2

Manufacturing areas have the responsibility of maintaining work stations or work surfaces. The janitorial service will maintain those areas pertaining directly to the facility. Where possible, cleaning is accomplished during non-work periods with components and instruments covered to protect against contamination.

2.4.3

Manufacturing must make arrangements with Hughes Maintenance for routine janitorial services in manufacturing areas. Quality Product Assurance will verify that services have been properly performed. Any discrepancy is directed to the area Supervisor who will determine the cleaning responsibility. If the discrepancy is janitorial responsibility, the Supervisor is to contact the Maintenance Service Desk for corrective action.

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1.12.1

Controlled Area
Class I and Class II
Sample Maintenance Schedule

Month/Year

Area/Room

TASK	ACTION	MINIMUM FREQUENCY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Work Surfaces (Active)	Wipe or Vac	Daily																															
Waste Baskets	Empty	Daily																															
Sinks and Drinking Fountains	Wash	Daily																															
QA Verification		Daily																															
Floors and Foot Mats	Wet Mop/Vac	Twice/Week																															
QA Verification		Twice/Week																															
Work Surfaces (Inactive)	Wipe or Vac	Weekly																															
QA Verification		Weekly																															
Walls and Surfaces Under 8 ft (Cl.I)	Wipe or Vac	Monthly																															
Cabinets and Shelving	Wipe or Vac	Monthly																															
Windows	Wash	Monthly																															
Air Registers (Inlet and Exhaust)	Wipe or Vac	Twice/Year																															
QA Verification		Monthly																															
Walls and Surfaces Under 8 ft (Cl.II)	Wipe or Vac	Twice/Year																															
QA Verification		Twice/Year																															
Ceilings	Wipe or Vac	Yearly																															
Overhead Cranes	Wipe or Vac	Yearly																															
Walls and Surfaces Over 8 ft	Wipe or Vac	Yearly																															
QA Verification		Yearly																															

Figure 2. Controlled Area Sample Maintenance Schedule

Clean Room
Class 10,000 and Class 100,000
Sample Maintenance Schedule

Month/Year

Area/Room

TASK	ACTION	MINIMUM FREQUENCY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Work Surfaces (Active)	Wipe or Vac	Daily																															
Waste Baskets	Empty	Daily																															
Sinks and Drinking Fountains	Wash	Daily																															
Floors and Foot Mats	Wet Mop/Vac	Daily																															
Work Surfaces (Inactive)	Wipe or Vac	Daily																															
Tacky Mats	Alcohol Wash or Tear Away	Daily																															
Cabinets and Shelving (Cl. 10,000)	Wipe or Vac	Daily																															
QA Verification		Daily																															
Walls and Surfaces Under 8 ft	Wipe or Vac	Weekly																															
Cabinets and Shelving (Cl. 100,000)	Wipe or Vac	Weekly																															
QA Verification		Weekly																															
Windows	Wash	Monthly																															
Air Registers (Inlet and Exhaust)	Wipe or Vac	Monthly																															
QA Verification		Monthly																															
Overhead Cranes	Wipe or Vac	Twice/Year																															
Walls and Surfaces Over 8 ft	Wipe or Vac	Twice/Year																															
QA Verification		Twice/Year																															
Ceilings	Wipe or Vac	Yearly																															
QA Verification		Yearly																															

3.0

REQUIREMENTS

3.1

Indoctrination of Personnel

3.1.1

All personnel requiring regular access to Controlled Areas and Clean Rooms shall complete an indoctrination on Clean Room procedures.

3.1.2

A 15-minute videotape on Controlled Areas and Clean Rooms is available from Video Services or the Manufacturing Engineering Laboratory (MEL). The name, source code, and payroll number of persons viewing the indoctrination tape shall be sent to MEL to be included in the indoctrinated personnel roster. The roster is updated and distributed periodically; current copies are available from MEL.

3.2

Controlled Area Smocks (Class I and Class II)

3.2.1

Smock material in Controlled Areas, other than Clean Rooms, shall be a cotton-polyester blend of 20% minimum cotton, or inherently static safe polyester fabric with conductive nylon filament. Disposable smocks of spun olefin may be used in place of fabric. Smocks in areas handling static sensitive devices shall comply with smock requirements of HPR 61500.

3.2.2

Controlled Area smocks may have conventional open collar or military/mandarin collar. Hems and seams are closed and double stitched. Pockets, pleats, tucks, and belts are dust collectors and are not permitted on smocks.

3.2.3

Length of smock may be mid-thigh (fingertip) or longer. Sleeve length may be elbow length or longer, depending on product requirements.

3.2.4

Controlled Area smocks may be closed using buttons, zippers, or stainless steel snaps, provided that the closure is covered to prevent direct contact with critical hardware surfaces.

3.2.5

All protective garments shall be treated for static electricity control and certified by the laundering service. Smocks are subject to provisions of HPR 61500.

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- 3.3 Clean Room Garments (Class 10,000 and Class 100,000)
- 3.3.1 Garment material in Clean Rooms shall be 100% dacron or polyester that is inherently static safe with conductive nylon filament. Disposable garments designed specifically for Clean Room application may be used in place of fabric in Class 100,000 Clean Rooms.
- 3.3.2 Clean Room smocks shall have military/mandarin collar. Hems and seams are closed and double stitched. No pleats, tucks, belts, or pockets are permitted.
- 3.3.3 Smocks shall have closures of buttons, zippers, or stainless steel snaps with adjustment at the cuffs and collar to ensure a snug fit. Smocks shall be so designed that the closures are covered to prevent contact with critical hardware surfaces.
- 3.3.4 Smocks shall be knee length or longer. Sleeves shall be full length.
- 3.3.5 Head covering shall be of materials specified in 3.3.1. Personnel with beards shall wear beard covers.
- 3.3.6 Boot and shoe covers for general usage shall be constructed of nylon or polyester with a conductive non-skid sole.
- 3.4 Garment Usage
- 3.4.1 General Guidelines - All Areas
- 3.4.1.1 Smocks shall be worn to protect the work environment, and the work performed in it, from static and particulate contamination found on clothes.
- 3.4.1.2 Smocks shall be stored in lockers or in approved hanger area when not being worn. Smocks shall not be mixed with street clothes or stored on tops of lockers. Separate clothes racks shall be provided for smocks and street clothes.
- 3.4.1.3 Front snaps, zippers, or buttons shall be fastened when wearing smocks.
- 3.4.1.4 Protective garments shall not be worn outside the manufacturing area, test area, or locker rooms.
- 3.4.1.5 Gloves for general usage shall be constructed of nylon or polyester. When handling static sensitive devices, refer to MEI 1.12.4.
- 3.4.1.6 Smocks carried from one Controlled Area to another shall be carried in closed, preferably static-safe, plastic bags. Clean Room smocks shall not be carried from one Clean Room to another.

- 3.4.1.7 Smocks may not be taken home for laundering. Cleaning services use chemical treatments for static control and highly filtered fluids for contaminant control.
- 3.4.1.8 Rolled up sleeves are not permitted.
- 3.4.1.9 If hat and beard covers are required, they shall be worn in a manner to cover all possible hair. Sideburns and mustaches may be exposed.
- 3.4.1.10 Disposable smocks of spun olefin may be used in place of fabric smocks only where specified.
- 3.4.1.11 If shorter length sleeve smock is worn, street clothes shall not protrude beyond end of sleeve.
- 3.4.2 Soiled Garments
- 3.4.2.1 At any time while performing Controlled Area or Clean Room duties a garment becomes excessively soiled, promptly exchange for a clean garment.
- 3.4.2.2 Recommended Soiled Garment Exchange
- a. Class I and II - one change per week.
 - b. Class 100,000 - one change per week.
 - c. Class 10,000 - one change per three days.
- 3.5 Quality Assurance Provisions
- 3.5.1 QA shall verify compliance with the following:
- a. Particle control per 2.1.2
 - b. Temperature control per 2.1.3
 - c. Relative humidity control per 2.1.4
 - d. Document control per 2.1.5
 - e. Maintenance schedules per 2.4.1
- 3.6 Equipment
- | | |
|---|--|
| Particle counter - model #245
with printer model 129, or
equivalent | Royco Instruments, Inc
Menlo Park, CA |
| Temperature and relative
humidity recorder -
model 612X9-HT-00-00-7M-L
0-100°F, 0-100%RH,
or equivalent | Honeywell
Port Washington, PA |

3.7

Materials

Smocks, hoods, gloves, and boot covers	TBD
Beard covers, foam	MRO 50-1108
Disposable caps, general usage, blue	MRO 60-5086
Anti-static plastic bags, 8 X 10	MRO 821472-008
Disposable smock, general usage, medium, Stock #A6085-41	American Converters Irvine, CA
Disposable smock, general usage, large, Stock #A6085-42	American Converters Irvine, CA
Disposable caps, Clean Room, stock no. A6127-1	American Converters Irvine, CA
Tacky mat, 45 X 18	MRO 95-0120
Hand cream, lanoline and silicone free	MRO 95-0191

4.0

APPLICABLE DOCUMENTS

NOTE: The following documents of the latest issue in effect form a part of this MEI.

4.1

Government

FED-STD-209

Clean Room and Work Station
Requirements, Controlled
Environment

4.2

Hughes

HP 10-22

Controlled Areas, Requirements

HPR 61500

Protection of Static Sensitive
Devices

MDI 1.7.4

Environmentally Controlled
Facilities Requirements

MEI 1.12.4

Protection of Static Sensitive
Devices (SSDs)

QP 4.2.53

Cleanliness - Control and
Handling of Items with Special
Requirements

Videotape #069

Controlled Areas (15 minutes)

ATTACHMENT 2

1. SCOPE

1.1 Scope. This specification establishes the environmental air control requirements within controlled areas (See 6.1.1).

1.2 Classification. The process shall be classified in accordance with the following:

1.2.1 Classes. The controlled areas shall be one of the following classes specified in accordance with the airborne particulate count.

Class	Maximum No. of Particles Per Cu. Ft. 5 Micrometers and Larger
I	1,500
II	No requirement

1.2.2 Grades. The controlled areas shall be one of the following grades specified in accordance with the temperature.

Grade	Temperature ° F
A	72 ±2
B	72 ±5
C	75 ±10
D	No restrictions

1.2.3 Levels. The controlled areas shall be one of the following levels specified in accordance with the humidity.

Level	Relative Humidity Percent
1	37.5 ±7.5
2	50 maximum
3	65 maximum
4	No restrictions

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1.3 Superseding data. Clean areas are no longer governed by this specification. Clean areas previously governed by this specification are superseded by Fed. Std. No. 209 as follows:

Superseded HP 10-22 Classification	Superseding Fed. Std. No. 209 Designation
Class 100	Class 100
Class 10,000	Class 10,000
Class 50,000	Class 100,000
Class 100,000	Class 100,000
Grade A	72 \pm 2 °F
Grade B	72 \pm 5 °F
Grade C	75 \pm 10 °F
Grade D	No restrictions
Level 1	37.5 \pm 7.5% R.H. <u>1/</u>
Level 2	50% R.H., maximum
Level 3	65% R.H., maximum
Level 4	No restrictions

1/ Percent relative humidity.

2. APPLICABLE DOCUMENTS

2.1 The following documents of the latest issue in effect form a part of this specification to the extent specified herein:

STANDARD

Federal

Fed. Std. No. 209

Clean Room and Work Station Requirements,
Controlled Environment

SPECIFICATION

Military

MIL-C-45662

Calibration System Requirements

2.2 Other publications. The following documents of the latest issue in effect form a part of this specification to the extent specified herein:

American Society for Testing and Materials

F 25

Standard Method for Sizing and Counting
Airborne Particulate Contamination in Clean
Rooms and Other Dust Controlled Areas Designed
for Electronic and Similar Applications

3. REQUIREMENTS

3.1 Detailed requirements

3.1.1 Airborne particulate requirements. The airborne particulate level of a Class I controlled area shall not exceed 1500 particles, 5 microns and larger, per cubic foot.

3.1.2 Temperature requirement. The temperature in a controlled area shall be maintained within one of the grades in 1.2.2.

3.1.3 Humidity requirement. The humidity in a controlled area shall be maintained within one of the levels in 1.2.3.

3.2 General requirements

3.2.1 Area identification. Signs shall be posted in a conspicuous manner outside each entrance to a controlled area. The sign shall have the words HP 10-22 Controlled Area followed by the appropriate Class, Grade, and Level from 1.2.

3.2.2 Operational instructions. Instructions shall be posted in a conspicuous manner outside each entrance to a controlled area defining the operational procedures to be followed by personnel inside the area.

3.2.3 Calibration. All equipment required to control, monitor, and record parameters specified in 1.2.1, 1.2.2, and 1.2.3 shall be calibrated utilizing a calibration system established and maintained in accordance with MIL-C-45662.

3.2.4 Permanent log. A permanent log shall be maintained for each controlled area except Class II, Grade D, Level 4, for recording temperature, humidity, and airborne particle count.

3.2.5 Aerosol contaminant control. Mechanical vacuum pumps and compressed air which produce aerosol contaminants shall not be used in controlled areas where spacecraft hardware is being manufactured, unless the following applicable requirements are met.

3.2.5.1 Mechanical vacuum pumps. Mechanical vacuum pumps shall be vented outside the area or equipped with exhaust filters designed to remove hydrocarbon aerosols.

3.2.5.2 Compressed air. Compressed air used in a Class I area shall be filtered through a 5.0 micrometer absolute, or finer, filter prior to use. The hydrocarbon and water aerosols in the compressed air shall be controlled so that the air exhausting from pneumatic tools and equipment does not visually contaminate hardware surfaces in both Class I and Class II areas.

3.3 Personnel requirements

3.3.1 Personnel attire

3.3.1.1 Protective garments. Clean protective garments shall be worn by all personnel entering controlled areas.

3.3.1.2 Sizes. Protective garments shall be available in sufficient sizes to fit all personnel requiring access to the controlled areas. Socks shall be approximately knee length.

3.3.2 Smoking. Smoking shall be prohibited in controlled areas.

3.3.3 Eating and drinking. Eating of any description, and drinking, except for self-contained fountains, shall be prohibited in controlled areas.

3.4 Specific area requirements

3.4.1 Class I controlled area

3.4.1.1 Airlocks. An airlock shall be provided for Class I controlled areas opening directly to the out-of-doors.

3.5 Maintenance requirements

3.5.1 Maintenance records. A check off list shall be maintained for each controlled area showing the maintenance schedules and the cleaning operations performed. The check off list shall be posted in a conspicuous location inside the area, and kept up to date. Each entry shall be verified by the cognizant Quality Assurance activity.

3.5.2 Maintenance schedule. Controlled areas shall, as a minimum, be cleaned as specified in Table I.

TABLE I CONTROLLED AREA MAINTENANCE SCHEDULE

Area	Method	Minimum Frequency
All floor areas (including air lock)	Vacuum Wet mop <u>1/</u>	Weekly Semiweekly
Work surfaces (active benches, etc.)	Wipe or vacuum	Daily
Unused benches and equipment tops	Wipe or vacuum	Weekly
Waste baskets	Empty	Daily
Drinking fountains, Sinks	Wash	Daily
Air duct inlets and exhausts, and plenum chambers	Wipe or vacuum	Monthly

1/ In screen rooms or where wet mopping may cause electrical hazard, vacuuming alone is permitted.

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4. QUALITY ASSURANCE PROVISIONS

4.1 Inspection methods. The following inspection methods shall be used as applicable to determine compliance with 3.1.

4.1.1 Particle counting methods. Compliance with 3.1.1 shall be determined by either automatic equipment employing light scattering principles or the microscopic method defined in ASTM F 25 with the exception that a Globe and Circle Pattern reticle may be used instead of the Linear Scale reticle.

4.1.1.1 Particle count frequency. The particle count frequency shall be as stated below. All particle counts shall be recorded in the area log book, and each entry shall be verified by the cognizant Quality Assurance activity.

4.1.1.1.1 Certification monitoring. The initial certification of a new Class I controlled area or the recertification of a Class I controlled area that has undergone major renovation i.e. installation of utilities, room additions, etc. shall be performed under conditions simulating, as nearly as practical, anticipated production operations. Actual production activities shall not begin in a Class I controlled area until the area has been officially certified (see step 2). The sampling frequency during certification shall be as stated below:

Step 1. Samples shall be taken at no less than 2 hour intervals until the average count (see 4.1.1.3) from all locations (see 4.1.1.2) for four consecutive samplings is shown to be within specification limits.

Step 2. After step 1 has been completed, the cognizant Quality Assurance activity shall officially certify the area by issuing a "letter of certification" to the area supervisor. After the area has been certified, the area supervisor shall have appropriate signs posted at all entrances in accordance with 3.2.1. Subsequent minimum (routine) sampling intervals shall be as specified in 4.1.1.2.

4.1.1.1.2 Routine monitoring. During routine monitoring of a certified Class I controlled area the minimum sampling frequency shall be once every 5 days of occupancy. The samples shall be taken in the immediate proximity of hardware items in work during periods of normal occupancy and work activity.

4.1.1.2 Monitoring locations. The schedule below shall be used in determining the minimum number of sampling locations within a Class I controlled area during certification and routine monitoring. When automatic particle counting devices are used, a minimum of 5 cubic feet (0.14 cubic meter) of air shall be sampled at each sampling location.

<u>Size of Area, Square Feet (Square Meters)</u>	<u>Number of Location</u>	
	<u>Certification</u>	<u>Routine</u>
up to 2,500 (232.3)	4	2
2,501 to 7,500 (232.4 to 696.8)	8	4
over 7,500 (696.8)	12	6

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4.1.1.3 Particle count average. Individual counts on samples from a given area shall be averaged. The value of this average shall be used to determine the count of the area. If no individual sample exceeds the desired count by more than 20 percent and if the average is less than the desired count, the area can be considered within specification. If any one sample exceeds the desired count by more than 20 percent or if the average is more than the desired count, remedial action as to the cause shall be taken.

4.1.1.4 Out-of-specification area. After remedial action has been accomplished on an out-of-specification Class I controlled area, air samples shall be taken in accordance with 4.1.1.1.2 and 4.1.1.2 until the average particle count (see 4.1.1.3) meets the values of 1.2.1.

4.1.2 Temperature monitoring. For all areas except Grade D, the temperature shall be monitored as follows:

4.1.2.1 Method. Temperature shall be measured by either a glass thermometer or by an automatic continuous recording device.

4.1.2.2 Monitoring. Readings taken with a glass thermometer shall be recorded in the area log at least once during every 5 days of occupancy. Each entry shall be verified by the cognizant Quality Assurance activity. Automatic continuous recording device charts shall be dated and maintained on record.

4.1.3 Relative humidity monitoring. For all areas except Level 4, the relative humidity shall be monitored as follows:

4.1.3.1 Method. Relative humidity shall be measured by either a wet and dry bulb thermometer used in conjunction with a psychrometric chart, or by an automatic continuous recording device.

4.1.3.2 Monitoring. Readings taken with a wet and dry bulb thermometer shall be recorded in area log at least once every 5 days of occupancy. Each entry shall be verified by the cognizant Quality Assurance activity. Automatic continuous recording device charts shall be dated and maintained on record.

4.2 Visual examinations and inspections. Visual examinations and inspections shall be performed by the cognizant Quality Assurance activity at least once during every 5 days of occupancy to determine compliance with 3.2, 3.3, 3.4, and 3.5. Deviations from the stated requirements shall be reported immediately to the area supervisor for corrective action.

5. PREPARATION FOR DELIVERY (Not applicable)

6. NOTES**6.1 Definitions**

6.1.1 Controlled areas. A controlled area is one in which airborne particulate contamination is controlled to a higher degree than in conventional air conditioned industrial areas, but to a lesser degree than in clean rooms maintained in accordance with Fed.Std. No. 209. Cleanliness in controlled areas is maintained by good maintenance procedures, material handling control and enforcement of employee discipline.

6.1.2 Micron (micrometer). A micron is a unit of measurement equal to one millionth of a meter or 0.0000394 inch. (e.g. 25 microns is approximately 0.001 inch).

RELEASE AND REVISION RECORD

Rev	Authority	Description	Release	
			Date	Approval
Orig thru C	--	Records of previous changes are contained in the Engineering Support Department history file.	--	--
D	CA 70018-1	Incorporated Amendment No. V of revision C' P14: Para 3.8.2, line 2 changed 70 fpm to 90 fpm	9/22/70	<i>W. H. Hadyn</i> D. C. Smith
E	CA 43740-1	P20: Paras 4.4.1, 4.4.2, 4.5.1, 4.6.1 and 4.6.2 revised.	5/11/71	<i>E. A. Smith</i> D. C. Smith
F	CMER 45151	Extensively revised.	2/21/73	<i>R. L. Duffin</i> R. Weekley
G	CMER 45151	P2: Para 1.3 revised and reworded and added relative humidity. P3: Paras 3.1.2 and 3.1.3 added. Para 3.2.4 added "except Class II, Grade D, Level 4". P4: Para 3.5.1 revised. Para 3.5.2 and Table I added. P5: Section 4 extensively revised and re-numbered and Para 4.2 added.	12/28/73	<i>E. A. Scott</i> R. Weekley
H	CMER 46305	P3: Para. 3.2.5 added. P5: Para. 4.1.1.1.1, extensively revised, was "Initial certification". Para. 4.1.1.1.2, added last sentence. Para. 4.1.1.2, was "Sampling locations", revised and added number of certification locations. P6: Para 4.1.1.4, added 4.1.1.1.2.	2/26/74	<i>E. A. Scott</i> R. Weekley

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ATTACHMENT 3

JSC 08962

REV. U.

COMPILATION OF VCM DATA OF NONMETALLIC MATERIALS

APPROVED BY:

A handwritten signature in dark ink, appearing to read "M. W. Steintal", is written over a horizontal line.

M. W. STEINTAL, ES5
STRUCTURES AND MECHANICS
DIVISION

PREPARED BY MCDONNELL DOUGLAS TECHNICAL SERVICES
COMPANY - HOUSTON ASTRONAUTICS DIVISION (MDTSCO-H)

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COMPILATION OF VCM DATA OF NONMETALLIC MATERIALS

INTRODUCTION

The purpose of this report is to present in a useful form, the numerical values of VCM data accumulated from various test laboratories/facilities which conduct VCM tests.

CAUTION

VCM DATA PRESENTED HEREIN, WITH TEST REPORT REFERENCE DESIGNATIONS OF X3A-XX, 7X-XXX (WSTF), JPL-XX, GSXXXX, AND SRI-XX HAVE BEEN OBTAINED USING THE INTENT OF THE LATEST REVISION OF SP-R-0022, "SPECIFICATION-VACUUM STABILITY REQUIREMENTS FOR POLYMERIC MATERIALS FOR SPACECRAFT APPLICATIONS" AS THE TEST SPECIFICATION. THE REMAINING DATA WERE NOT OBTAINED USING THE REQUIREMENTS OF THIS SPECIFICATION, AND IN THESE CASES, THE TEST REPORTS MUST BE REFERRED TO THE TESTING CRITERIA.

The data are divided into two parts for the user's convenience; Part I is sorted by material application or category (i.e. adhesives, coatings, compounds, etc.) while Part II is sorted by the manufacturer's designation. Specific subsets of the application areas can be found in the table of contents. In Part II the manufacturer's designations are listed starting with alpha characters first and then numeric (e.g. Stycast resin 2850 is located ahead of Stycast resin 2862 and both are ahead of 980-B-702 (silicone rubber)).

TABLE HEADING EXPLANATION

To conserve space, abbreviations have been used in the tables of data. The following are descriptions/interpretations given to the various headlines used.

Material Name - Manufacturer's designation, name, or abbreviated name of material, component, assembly, etc., that has been tested.

H4-ID - Designation number to identify various manufacturers. Numeric references have been taken from the "Defense Supply Agency Cataloging Handbooks H4-1, H4-2". Alpha-numeric references are delineated in either E37-01-012-A "Apollo Requirements Document Code List" or JSC 10654 "NASA Manufacturer Codes".

GEN-ID - Generic identification code consisting of six alpha characters to identify functional or design usage data and generic/chemical composition data. The code is an updated version of the NASA materials code used in COMAT and is contained in Appendix A of this report.

TWL - Total weight loss in percent as measured per SP-R-0022A procedures (equivalent to TML - total mass loss in percent).

VCM - Volatile condensable materials in percent measured using SP-R-0022A procedures.

REFERENCE - The test report number from which the data presented has been abstracted.

PC HOURS - Refers to the length of time, in hours, (or as specified) the test sample was pre-conditioned prior to being subjected to the particular test. "ARFM" stands for as received from manufacturer with no known post cure other than that normally performed by the manufacturer.

PC TEMP - Refers to the temperature in degrees centigrade, except where noted, at which the sample was pre-conditioned prior to the VCM determination. The suffix "v" after the preconditioning temperature means preconditioning was done in vacuum. The suffix "RT" or "AMB" means preconditioning was done at ambient room temperature.

SEQUENCE NO. - The sequence number refers to a computer programming reference number and has no significance except to assist in having the data printed out by computer.

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REFERENCE DOCUMENTS/SPECIFICATIONS

1. Anon, "General Specification-Vacuum Stability Requirements of Polymeric Material for Spacecraft Applications", JSC Specification SP-R-0022A, September 1974.
2. Anon, "Federal Supply Code for Manufacturers, United States and Canada" (Name to Code), Cataloging Handbook H4-1.
3. Anon, "Federal Supply Code for Manufacturers, United States and Canada" (Code to Name), Cataloging Handbook H4-2.
4. Anon, "Apollo Requirements Documents Code List" Lockheed Document E37-01-012-A Rev. 64, LEC, September 1971.
5. M. W. Steinhil, "NASA Manufacturers Codes", JSC Report 10654.

ATTACHMENT 4

SP-R-0022A
SEPTEMBER 9, 1974

SUPERSEDING
SP-R-0022
DECEMBER 12, 1969

1.1.3

GENERAL SPECIFICATION
VACUUM STABILITY REQUIREMENTS OF POLYMERIC
MATERIAL FOR SPACECRAFT APPLICATION.



National Aeronautics and Space Administration
LYNDON B. JOHNSON SPACE CENTER
Houston, Texas

SPECIFICATION
VACUUM STABILITY REQUIREMENTS OF POLYMERIC
MATERIAL FOR SPACECRAFT APPLICATION

Prepared by

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Section

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Structures & Mechanics Division

Approved by

Wendell C. Bond
Engineering & Development
Directorate

This specification has been approved by the Johnson
Spacecraft Center and is available for use by JSC and
associated contractors.

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1.0 PURPOSE

The purpose of this document is to establish outgassing requirements and test guidelines for polymeric materials used in the space thermal/vacuum environment around sensitive optical or thermal control surfaces.

2.0 REQUIREMENTS

The control and verification of material outgassing to the guidelines of this document are based on the following requirements:

- a. The polymeric materials used in the thermal/vacuum environment shall not contaminate the sensitive surfaces within an assembly.
- b. The polymeric materials used in any application shall not affect the sensitive surfaces of any adjacent equipment.

The material shall have a maximum total mass loss (TML) of 1.0 percent of the original specimen mass and a maximum volatile condensable material (VCM) content of 0.1 percent of the original specimen mass when tested in accordance with the test procedure in paragraph 6.

3.0 SCOPE

The scope of this document covers the control of polymeric materials used near or adjacent to optical or thermal control surfaces that are exposed to the thermal/vacuum environment of space. This document establishes the requirements and defines the test method to evaluate polymeric materials used in the vicinity of these surfaces in space applications.

4.0 SELECTION AND VERIFICATION REQUIREMENTS

Use of polymeric material near optical or thermal control surfaces shall be restricted to those materials which have a maximum volatile condensable material content of 0.1 percent and a total mass loss of 1.0 percent or less when tested in accordance with the test method described in paragraph 6. NASA JSC will provide to the contractor(s) a list of approved materials for use in the thermal/vacuum environment upon request. NASA JSC also maintains a complete file (JSC 08962A) of all materials tested.

The use of materials that have been tested but failed the requirements of this specification may be allowed if the contractor can provide rationale for their use that is approved

by NASA JSC. The following are examples of some considerations for use as rationale for a material that has failed the VCM or mass loss requirements:

- a. The material may be brought within vacuum stability limits by vacuum baking for a specified period of time (usually 48 hours at maximum use temperature at a pressure of less than 10^{-6} torr).
- b. If material cannot be vacuum baked and its exposed area is 13 cm² or less, and the material is out of line-of-sight of payload surfaces and other contamination critical surfaces, total mass loss may be up to 3.0% and volatile condensable material up to 1.0%.
- c. If total mass loss is greater than 1.0% and $VCM \leq 0.1\%$ and it can be shown that contributions to TML greater than 1.0% are due to sorbed water vapor, the material may be used.
- d. The material is the only satisfactory choice from a functionality viewpoint for the particular application.
- e. The total mass of materials selected under 4b and 4d above and used in any given compartment will be monitored and reviewed periodically to insure that compartmental peculiar problems do not evolve.
- f. Materials previously tested and found acceptable per MSFC 50M02442 may be used.

5.0 IMPLEMENTATION

The contractor shall provide for NASA JSC approval, a list of all polymeric materials selected for use around sensitive surfaces or in the same defined compartment as optical or thermal control surfaces. The following information is required.

- a. Manufacturer's trade name
- b. Manufacturer of the material
- c. Thermal vacuum stability (VCM and TML) data
- d. Rationale for use of material that failed the requirements of paragraph 4.0 and a report of the weight and surface area used.
- e. Materials that have not been tested should be submitted to JSC/ES5 for testing utilizing JSC form 2035B.

6.0 TEST PROCEDURES

6.1 PURPOSE. The purpose of this test is to measure total mass loss and volatile condensable material content of polymeric materials under controlled laboratory conditions. The following test procedure outlined below was extracted from NASA White Sands Test Facility Operational Checkout Procedure 200-013 entitled "Determination of Weight Loss and Volatile Condensable Components of Polymeric Material", June 1974. The use of any other test equipment and/or procedure must be approved by NASA-JSC.

6.2 TEST CONDITIONS. The test on polymeric materials shall be conducted under the following conditions:

Pressure	10^{-6} torr or less
Temperature of specimen	$125^{\circ}\text{C} \pm 1^{\circ}\text{C}$
Temperature of condensable plates	$25^{\circ}\text{C} \pm 1^{\circ}\text{C}$
Vacuum exposure time	24 hours

6.3 CRITERIA OF ACCEPTABILITY. The material shall have a volatile condensable material content of less than 0.1 percent of the original mass of the specimen. The total mass loss of the material shall not exceed 1.0 percent of the original mass of the specimen.

6.4 TEST EQUIPMENT. All laboratory test instrumentation shall be in current calibration and shall reflect appropriate documentation from the applicable calibration laboratory. The test equipment shall consist of the following:

- A vacuum system capable of maintaining 10^{-6} torr for a period of 24 hours.
- Specimen holder made of stainless steel or aluminum. The specimen holder shall be nominally 3.8 cm long and 1.25 cm in diameter.
- Collector plate shall be made of a highly polished stable metal surface. The collector plate shall be 3.8 cm in diameter.
- The test apparatus shall be made of copper. The apparatus shall be such that multiple specimen holders and collector plates can be accommodated at one time. The sample section shall be capable of maintaining the samples at $125 \pm 1^{\circ}\text{C}$ and maintaining the collector plates at $25 \pm 1^{\circ}\text{C}$.

6.5 SAMPLE PREPARATION.

- 6.5.1 Specimen Size. Materials to be tested shall be prepared in 100 to 300 milligram specimen sizes and placed in stainless steel or aluminum holders after preparation as specified below.
- 6.5.2 Solid Materials. Specimens shall be cut into small pieces having 0.15 cm maximum dimension. Samples shall be placed in a desiccator after preparation and remain there until the samples are placed in the test chamber.
- 6.5.3 Coatings. Materials that are normally used as coatings shall be applied to aluminum foil or Teflon sheet and prepared as noted in paragraph 6.5.2.
- 6.5.4 Solvent Containing Materials. Prior to testing solvent containing materials, such as inks and paints or room temperature cured materials, the sample shall be preconditioned for 24 hours at $65 \pm 1^\circ\text{C}$ in an air circulating oven to simulate the material exposure up to the time of launch.
- 6.5.5 Tapes. Tapes shall be tested in the as-applied configuration using aluminum foil or Teflon sheet as an application substrate and prepared in accordance with paragraph 6.5.2.
- 6.5.6 Liquids. Liquids shall be tested in the as-received state.
- 6.5.7 Cure Procedures. All material shall be cured or applied in accordance with the manufacturer's procedures or the applicable contractor process specification prior to test.

6.6 TML AND VCM MEASUREMENT.

- 6.6.1 Initial Mass Determination. The VCM collector plate and specimen holder mass shall be measured. Specimens shall be tested and their mass measured after being desiccated for 24 hours.
- 6.6.2 Specimen Insertion. The weighed samples shall be placed in the compartments of the heating block and the VCM collector plates shall be fastened to the cooling block of the apparatus.
- 6.6.3 Pressure. The system shall be evacuated and held at a maximum pressure of 10^{-6} torr.

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- 6.6.4 Application of Heat. When the unit has reached 10^{-6} torr, the specimens shall be heated to $125^{\circ}\text{C} \pm 1^{\circ}\text{C}$, and maintained for 24 hours. The VCM collector plates shall be maintained at $25^{\circ}\text{C} \pm 1^{\circ}\text{C}$ during the test.
- 6.6.5 Specimen Removal. The specimens in their holders and the VCM collector plates shall be removed from the apparatus and immediately placed in a desiccator.
- 6.6.6 Final Mass Determination. Measure the mass of the specimens and the collector plates as soon as possible after removal from the VCM apparatus, and record.

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4.6 CALIBRATION MANAGEMENT PLAN

HUGHES

Space and Communications Group

GOVERNMENT ELECTRONICS SYSTEMS DIVISION

HS256C-1045-0059

CALIBRATION MANAGEMENT PLAN

FOR THE HIGH RESOLUTION MICROWAVE SPECTROMETER SOUNDER (HIMSS) INSTRUMENT PROGRAM

AN INSTRUMENT FOR NASA'S EARTH OBSERVING SYSTEM

PRELIMINARY

OCTOBER 1990

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1. INTRODUCTION

1.1 Scope of the Calibration Management Plan

The Calibration Management Plan describes the management and technical approach for the calibration and validation programs for the high resolution microwave spectrometer sounder (HIMSS).

With respect to the management of the calibration and validation program, the Calibration Management Plan describes the basic philosophy of the program, the organizations involved, their responsibilities, and the specific functions each will perform. It also describes the specifications and procedures which will be generated to guide the execution of the calibration test program, and the calibration design reviews which will be conducted.

The plan also addresses logistics aspects of the calibration of the HIMSS instrument are addressed. It describes the facilities that will be used and their availability. Activities that will be performed prior to instrument delivery are described, and a schedule of of these activities is included. The instrument configuration during the various calibration activities is summarized.

The plan addresses technical aspects of the calibration program including calibration and characterization tests representing the manner in which the instrument will operate in orbit, mathematical (analytic) models, calibration in terms of physical standards and standard processes, cross-calibration and comparison of sensors before launch and in-orbit.

In the specific case of the HIMSS instrument, the technical details of the calibration and validation program need to be addressed individually. Instrument calibration prior to launch will be the responsibility of Hughes Aircraft Company (HAC), the instrument developer. Discussion of the technical approach for the calibration program is therefore included in the Calibration Management Plan.

Data product validation, which involves correlation of the processed data with ground observed measurements and with the measurements of other instruments, is the responsibility of Remote Sensing Systems, the algorithm developer. However, Hughes will actively support the validation program through all its phases. The systems engineering manager, under the direction of the performance assurance manager, will take the lead in this support activity, and will coordinate activities from other HIMSS organizations as required.

1.2 List of Acronyms

CCDR	Critical Calibration Design Review
CDR	Critical Design Review
PCDR	Preliminary Calibration Design Review
PDR	Preliminary Design Review

2. APPLICABLE DOCUMENTS

HIMSS Instrument Verification Plan, HS TBD

HIMSS Calibration Specification, TBD

HIMSS Sensor Calibration Test Procedure, TBD

HIMSS Antenna Pattern Calibration Test Procedure, TBD

3. CALIBRATION MANAGEMENT ORGANIZATION

3.1 Calibration Management Responsibility

Calibration and validation activities for the HIMSS instrument involve a coordinated effort among four organizations within the HIMSS program: systems engineering, instrument integration and test, product assurance, and the antenna subsystem organization. The placement of these organizations within the HIMSS program structure is shown in Figure 3.1-1.

The responsibilities of each of these organizations and the tasks they will perform is summarized in Figure 3.1-2. Overall responsibility for calibration and validation activities lies with the performance assurance manager. The systems engineering manager, supported by his engineering staff, is responsible for specifying calibration requirements and formulating the calibration test program.

The instrument integration and test task manager and the antenna subsystem task manager are each responsible for generating the detailed procedures which will be used to conduct calibration testing in their respective areas: sensor calibration and antenna pattern calibration. These procedures are reviewed and approved by the systems engineering manager, who assures that the procedures reflect and satisfy the requirements of the calibration program contained in the Calibration Management Plan.

The product assurance manager is responsible for verifying that the calibration activities are conducted in accordance with the procedures, and that the test data are documented fully and completely. Systems engineering verifies compliance of the test results with the calibration requirements.

3.2 Calibration Management Interfaces

As shown in Figure 3.1-2, each of the four organizations involved in calibration and validation activities reports to the HIMSS performance assurance manager. The systems engineering manager, instrument integration and test task manager, the product assurance manager, and the antenna subsystem task manager have well defined responsibilities. A coordinated effort among the four organizations is assured by both the formal HIMSS program review cycle, and informally, through nearly daily face-to-face interactions. The weekly program manager reviews, in which each of the four participates and reports progress in his area, provides the formal structure for coordinating activities.

3.3 Calibration Management and Implementation Plan

After contract award, a Calibration Management Implementation Plan will be formulated. This plan will describe the detailed activities which will effectively implement the requirements of the Calibration Management Plan.

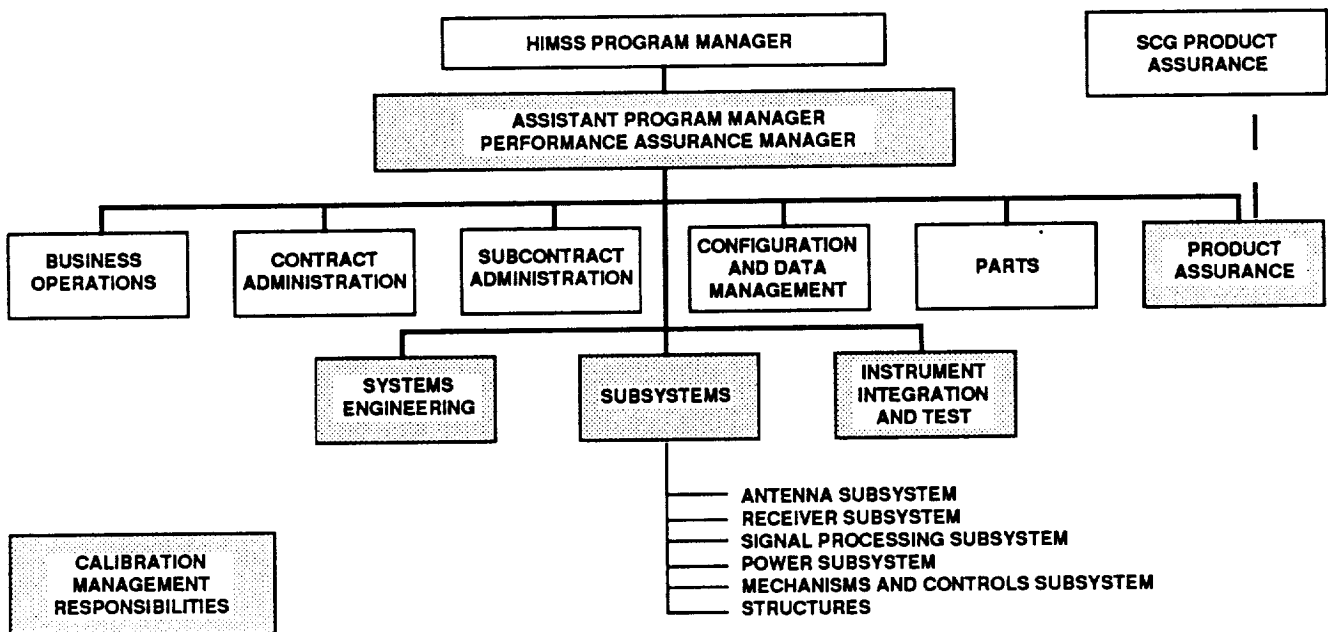


Figure 3.1-1. Management Organization for the HIMSS Instrument Program.

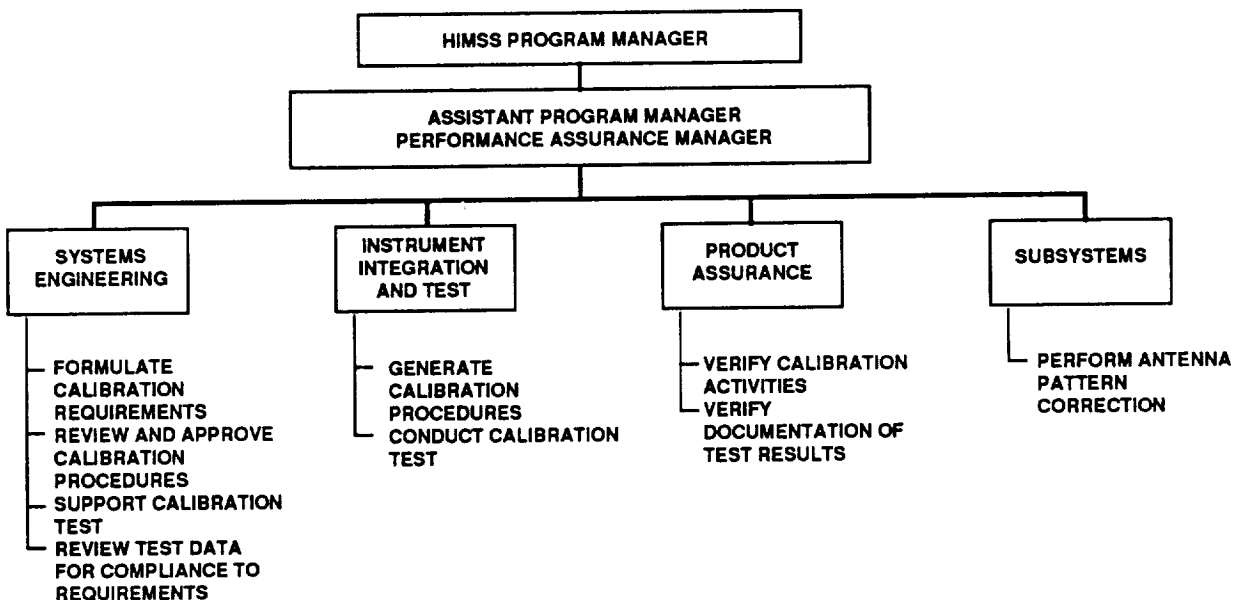


Figure 3.1-2. Responsibilities and Functions of Organizations involved in Calibration Management Activities.

4. CALIBRATION AND VALIDATION METHODOLOGY

4.1 Calibration Methodology

4.1.1 Calibration Program

The calibration program for the HIMSS instrument is conducted in accordance with a structured methodology. The process begins with the establishment of calibration requirements, as well as calibration test requirements, by systems engineering. These are documented in the HIMSS Calibration Specification and are reviewed at the Preliminary Calibration Design Review (PCDR). Based on these requirements, the integration and test and antenna subsystem task manager formulate detailed procedures for the conduct of calibration testing. These procedures are reviewed and approved by systems engineering, and the procedures are placed under configuration control. At the Critical Calibration Design Review (CCDR), these procedures are discussed together with estimates of calibration accuracy which can be achieved.

Calibration testing is conducted in accordance with these procedures, the test results are reviewed by systems engineering to verify compliance with the stated calibration requirements.

The schedule for the calibration program is shown in Figure 4.1-1.

4.1.2 Calibration Design Reviews

The calibration design reviews are scheduled as shown in Figure 4.1-1.

4.1.2.1 Preliminary Calibration Design Review

The PCDR is held in conjunction with the HIMSS instrument Preliminary Design Review (PDR).

The content of the PCDR presentation at the PDR is TBD.

4.1.2.2 Critical Calibration Design Review

The CCDR is held in conjunction with the HIMSS instrument Critical Design Review.

The content of the CCDR presentation at the CDR is TBD.

4.1.3 Calibration Procedures

Detailed procedures will be generated which will implement the requirements of the calibration test program as defined in the Calibration Management Plan. These detailed procedures document the tests to be conducted, the test equipment setup to be used, the configuration of the instrument at the time of the test, the data to be recorded, and the format to be used.

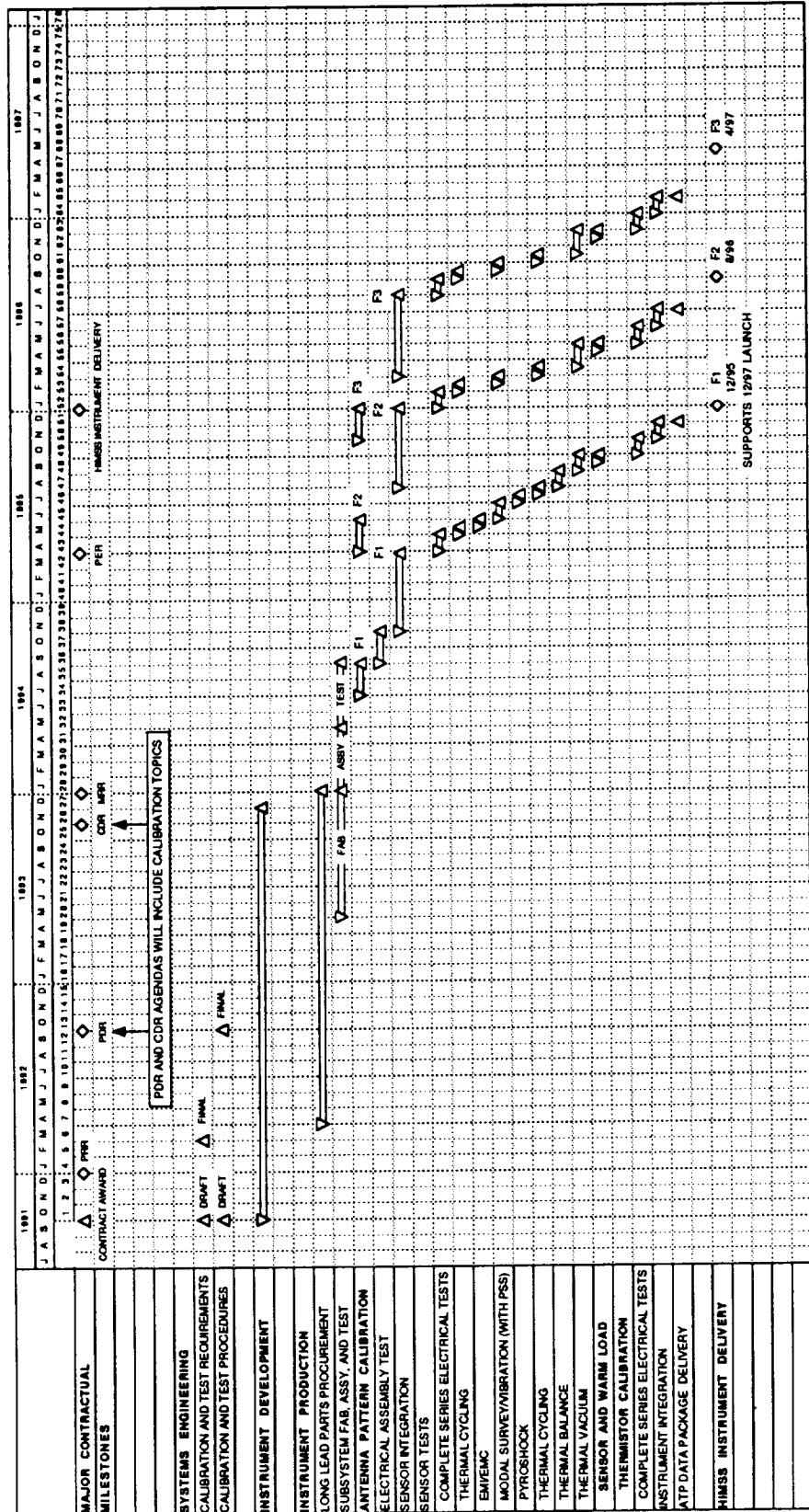


Figure 4.1-1. Master schedule for the HIMSS Calibration Program.

Two procedures will be generated for calibrating the HIMSS instrument: the HIMSS Antenna Pattern Calibration Test Procedure for calibrating the antenna pattern and the HIMSS Sensor Calibration Test Procedure for calibrating the gain and voltage output of the HIMSS instrument and the warm load thermistors. The gain and voltage outputs, together with the warm load physical temperature, are used to determine scene brightness temperatures, as discussed in Section 5.1.1.1.

4.1.4 Maintenance of Calibration Data

All data relating to HIMSS instrument calibration will be maintained at Hughes as a part of the permanent data record for each instrument. Calibration data will be provided to EosDIS in accordance with the requirements of TBS.

4.2 Validation Methodology

As indicated in Section 1.2, the data product validation activity is the responsibility of Remote Sensing Systems, which is generating the Validation Plan and the associated procedures. Hughes will actively support the data products validation program as required.

4.2.1 Validation Plan

The methodology to be employed in validating data products derived from the instrument shall be documented in the Validation Plan generated by Remote Sensing Systems, the algorithm developer.

4.2.2 Validation Design Reviews

Validation design reviews will be conducted by Remote Sensing Systems and will be supported by Hughes. The reviews will be scheduled and conducted in accordance with the Remote Sensing Systems' Validation Plan.

4.2.3 Validation Procedures

Validation procedures, describing the detailed process by which the Validation Plan will be implemented, will be generated by Remote Sensing systems, the algorithm developer. Hughes will support Remote Sensing Systems, as required, in generating these procedures.

5. TECHNICAL APPROACH

5.1 Instrument Calibration

5.1.1 Pre-launch Calibration and Characterization Tests

5.1.1.1 Instrument Calibration Technique

HIMSS instrument calibration is required in three areas: establishing the coefficients used in the antenna pattern correction algorithms, determining the coefficients relating the instrument digitized gain and voltage outputs to scene brightness temperature, and calibration of the flight thermistors in the two warm loads.

5.1.1.1.1 Calibration of Antenna Patterns

In order to properly determine power inputs over the sampled footprint, a detailed knowledge of the shape of the antenna pattern is required. The roll-off of the antenna pattern at each sampled frequency will be measured. Using these data, the appropriate coefficients are calculated. These coefficients are applied in the antenna pattern correction algorithms developed by Remote Sensing Systems.

5.1.1.1.2 Calibration of Instrument Gain and Voltage Outputs

The HIMSS instrument is a total power radiometer which quantifies scene brightness temperature (i.e., the brightness temperature of its field of view) in two ways: a course quantification indicated by the gain state of the receiver, and a fine quantification indicated by detector output voltage. Both gain and voltage readings are output from the instrument in a digitized form. These gain and voltage data, together with the calibration coefficients discussed below, provide a precise measure of scene brightness temperature.

The calibration coefficients are determined during the final thermal cycle in thermal vacuum testing, when instrument gain and voltage output as a function of known target brightness temperatures is determined. Three targets are used in this process. A test target cooled by liquid nitrogen to approximately 80 Kelvin (K) provides a low temperature calibration point. The flight warm loads provide the warm calibration point. A second test target, warmed by internally mounted heaters to various temperatures, simulates Earth's brightness temperatures. This latter target is called the Earth test target.

By measuring the gain and voltage output by the instrument for various Earth test target brightness temperatures, the calibration coefficients relating scene brightness temperature to output gain and voltage can be established. Section 5.1.1.4 describes the radiometer transfer function in which these

coefficients appear. This process is repeated with the instrument stabilized at three different temperatures, as shown in Figure 5.1-1, so that any subtle changes in calibration coefficients with instrument temperature can also be established. The instrument is calibrated for a range of Earth brightness temperatures, as indicated by Figure 5.1-2.

Internally mounted precision platinum thermistors indicate the temperature of each of the two test targets and of the warm loads to within ± 0.1 K, allowing for the precise determination of the calibration coefficients.

5.1.1.1.3 Calibration of Flight Thermistors

Flight thermistors are mounted in the warm loads of the sensor. These thermistors provide data relating to the physical temperature of the warm loads, from which its brightness temperature is determined. Since this brightness temperature serves as the calibration point at the upper end of the range of gain and voltage outputs from the sensor, these thermistors play a primary role in the scan-to-scan calibration of the instrument.

These thermistors in the warm loads are identical to those used in the calibration test targets.

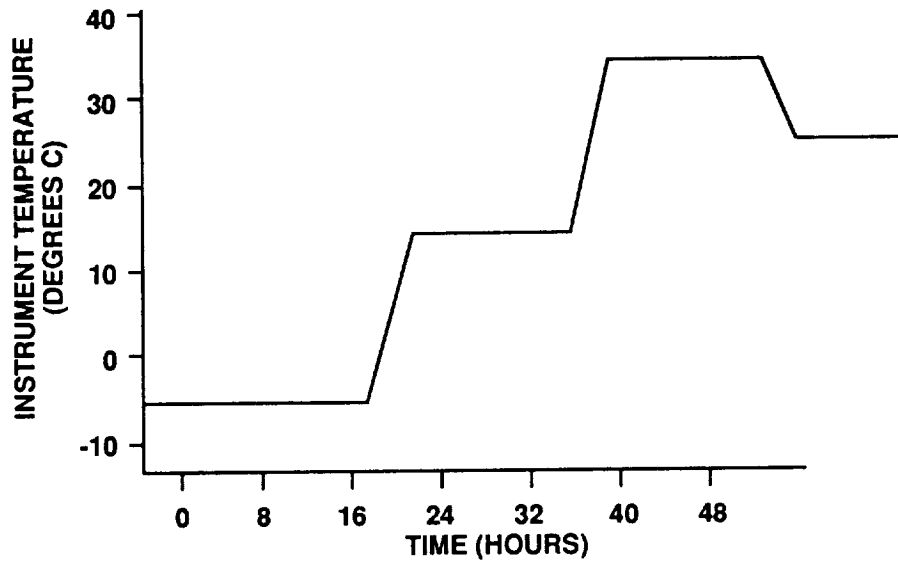
5.1.1.2 Physical Standards

Calibration of test instrumentation and traceability of test equipment back to secondary or primary standards is maintained at all times at Hughes. Hughes metrology practices are described in the Performance Assurance Plan, Section 8.17.

In addition to the maintenance of calibrated test equipment, one unique issue for the HIMSS instrument is maintenance of calibrated precision platinum thermistors. These thermistors are used to measure the temperatures of the warm loads, Earth test target, and the cold test target. These thermistors are $\pm 2\%$ precision platinum thermistors with a zero-power resistance of 2 Kohms at 25°C , equivalent to a temperature measurement accuracy of ± 0.1 K. They are delivered with calibration data, and the data are checked through independent tests at receiving inspection and/or prior to instrument calibration in thermal vacuum. Thermistors in the test targets are periodically recalibrated in accordance with HIMSS Performance Assurance Plan, Section 8.17.

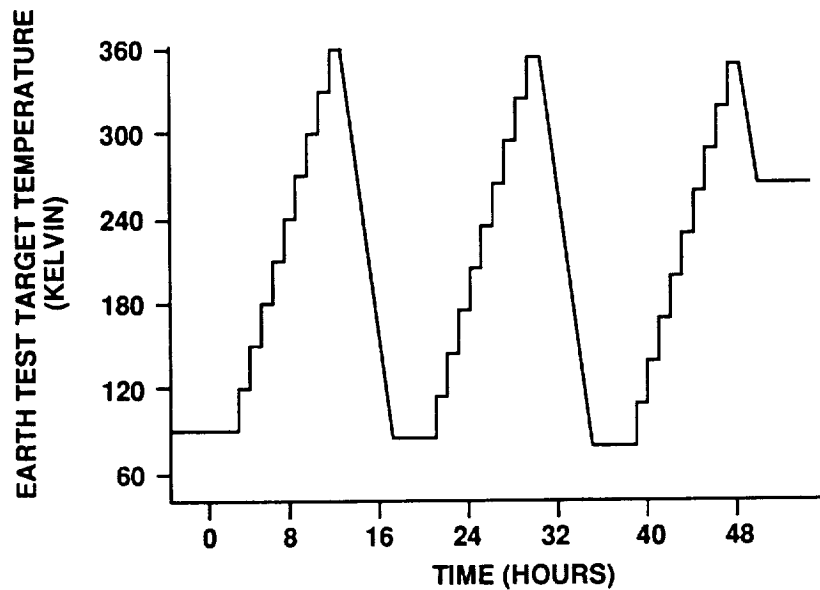
5.1.1.3 Cross-Calibration and Comparison of Sensors

It is desirable to cross-calibrate or compare the HIMSS instrument with other instruments prior to launch. Once the other instruments have been selected, they will be reviewed to determine which, if any, are good candidates for cross-calibration or comparison with the HIMSS instrument. If another instrument is deemed suitable, the details of the cross-



NOTE: 1) TRANSITIONS ARE APPROXIMATE
2) DWELL 8 HOURS AT EACH PLATEAU

Figure 5.1-1. HIMSS Instrument calibration is performed with the instrument stabilized at three different temperatures.



NOTE: 1) TRANSITIONS ARE APPROXIMATE
2) VARIABLE EARTH TEST TARGET TEMPERATURE IS APPROXIMATE

Figure 5.1-2. Variable Earth test target temperature transitions during calibration test.

calibration or comparison process will be developed. To the extent possible, the details of the calibration approach for the HIMSS instrument will be such as to facilitate integration with the calibration approach of other instruments.

5.1.1.4 Mathematical Models

5.1.1.4.1 Radiometer Transfer Function

The radiometer transfer function will be assumed to be linear with the following expression for scene brightness temperature:

$$T_b = T_w + b_0 + (T_c - T_w + b_1) * ((V - V_w) / (V_c - V_w)).$$

T_w and T_c are the effective cold test target and warm load physical temperatures, V_w , V_c , and V are the radiometer voltages representing the cold test target, warm load, and scene brightness temperatures respectively, and b_0 and b_1 are coefficients that depend on the hardware temperature. These coefficients are determined in the calibration test performed during system level testing in thermal vacuum.

5.1.1.4.2 Instrument Accuracy

There are a number of factors contributing to the overall HIMSS instrument brightness temperature error budget: receiver noise, imperfections in the antenna patterns, non-linearity and/or gain drift in the receiver, and cold sky reflector and warm load coupling.

Receiver noise, expressed as ΔT , is a random error arising from noise in the receiver elements. For the HIMSS instrument, receiver noise is expressed in terms of ΔT . ΔT is calculated taking into account the electronics noise figure, the measurement bandwidth, and the integration time.

Errors related to the antenna pattern arise from the antenna sidelobes and cross-polarization effects. This effect can be compensated for using an antenna pattern correction algorithm which makes use of the four adjacent pixels with an appropriate weighting.

Non-linearities in the receiver result in a deviation from the linear relationship assumed for the scene brightness temperature in 5.1.1.4.1. Non-linearity effects are generally quite small, as was the case on the Special Sensor Microwave/Imager (SSM/I). The extent to which non-linearities contribute to the overall error budget are determined during the calibration testing to define the coefficients b_0 and b_1 for the radiometer transfer function.

Gain drift can also contribute to the error budget. In the case of the HIMSS instrument, gain drift will affect the cold sky, warm load, and Earth brightness temperatures equally, and the

effect is nulled out.

Cold sky reflector and warm load coupling affects the purity of the energy input to the feeds from the cold sky reflector and the warm loads. Energy reflected from the cold sky reflector into the feeds as they move under the cold sky reflector may have some contribution arising from sources other than deep space. For example, radiation from the feeds themselves may reflect off the cold sky reflector back into the feeds. Similarly, coupling from extraneous sources into the warm loads may affect the energy sensed by the feeds as they pass under the warm loads. Generally warm load coupling is less of a concern than cold sky reflector coupling because of the proximity of the warm loads to the feeds.

It was determined on the SSM/I program that cold sky reflector and warm load coupling effects account for a very small portion of the total error budget.

An error budget for the HIMSS instrument reflecting all these error sources, as well as other minor effects, will be maintained throughout the HIMSS program. Maintenance of the error budgets throughout the HIMSS program will be the responsibility of the systems engineering organization.

5.1.1.5 Test and Calibration Fixtures Design

The test and calibration fixtures used in calibrating the HIMSS instrument are very simple. No elaborate design and development of test and calibration fixtures is required.

To perform antenna pattern calibration, structural fixtures are required for mounting the antenna and feeds on the antenna test range. These fixtures will be similar in concept to those used on SSM/I.

Calibration of sensor performance requires only the cold test target and the Earth test target. The cold test target is maintained at 80 K by circulating liquid nitrogen through it. The Earth test target is maintained at temperature by internally mounted heaters. High precision platinum thermistors mounted in the warm and cold loads are used to accurately determine the target temperature. For each of the two test targets, the target temperature and the uniformity of temperature over the target surface are determined by using several thermistors distributed throughout the target.

5.1.1.6 Calibration Software

No software is required specifically for calibration testing.

The antenna pattern calibration testing is performed using standard antenna test range test equipment and associated software.

Sensor calibration testing is performed during instrument acceptance testing as described in the Verification Plan. The calibration data are taken using the same instrument test equipment and associated software used for acceptance testing. No additional software beyond this is required.

5.1.1.7 Instrument Configuration during Calibration Test

Table 5.1-1 summarizes the instrument configuration during the various phases of calibration testing.

Test	Hardware Configuration
Antenna Pattern Correction	Main reflector, cold sky reflector, feeds mounted in flight top ring assembly
Sensor Calibration	Completed sensor except main reflector replaced by Earth test target and cold sky reflector replaced by cold test target
Warm Load Thermistor Calibration	Warm load assembly

Table 5.1-1. Instrument Configuration during calibration testing.

5.1.2 On Orbit Initialization and Calibration Maintenance

Paragraph 5.1.1.1.2 describes the formulation of calibration curves relating digitized gain and voltage outputs to the brightness temperature of the target. In essence, this process establishes the coefficients used to convert digitized gain and voltage data into a scene brightness temperature.

A similar process is used to initially calibrate the instrument on orbit, and to continue to calibrate it throughout its operational life (calibration maintenance). As the instrument spins, the feeds pass successively under the main reflector, the cold sky reflector, and the warm loads. When the instrument is in operation on orbit, this process is repeated during each

approximately 1.5 second scan period. The cold sky reflector provides a 3 K calibration point (i.e., the brightness temperature of deep space). The warm load provides a second calibration point.

The temperature of the warm loads varies depending on the current orbital conditions, but it is accurately measured by high precision platinum thermistors and the warm load temperature is downlinked to ground along with the other science data. The physical temperature of the warm loads is converted to a brightness temperature, which together with the cold sky brightness temperature gives the two required calibration points from which Earth brightness temperatures are determined.

As a result of this process, the HIMSS instrument is effectively calibrated during the first scan of on orbit initialization and is then recalibrated every 1.5 seconds throughout its operational life. No additional periodic calibration is required.

5.2 Data Product Validation

As indicated above, the data product validation activity is the responsibility of Remote Sensing Systems, which is generating the Validation Plan and the associated procedures. Hughes will support the data products validation program as required.

6. FACILITY REQUIREMENTS

The only facilities required for the conduct of calibration testing are the antenna test range and the thermal vacuum chamber. Both of these facilities are required for normal instrument verification test activities. No additional facilities are required.

Hughes has a number of test ranges and thermal vacuum chambers appropriate for testing the HIMSS instrument. No scheduling conflicts are anticipated. Should any conflicts arise, however, it is the responsibility of the program manager to resolve them.

7. ATTACHMENTS

TBD

4.7 VERIFICATION PLAN

HUGHES

Space and Communications Group
GOVERNMENT ELECTRONICS SYSTEMS DIVISION

HS256C-1045-0060

VERIFICATION PLAN

FOR THE

**HIGH RESOLUTION MICROWAVE
SPECTROMETER SOUNDER
(HIMSS)
INSTRUMENT PROGRAM**

**AN INSTRUMENT FOR NASA'S
EARTH OBSERVING SYSTEM**

PRELIMINARY

OCTOBER 1990

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1. INTRODUCTION

The HIMSS instrument design shall be environmentally verified and calibrated to be adequate for the Eos mission. This verification and calibration program, detailed herein, reflects the use to the largest extent, the SSM/I heritage both, in qualified hardware designs as well as in the verification program planning. This usage of space qualified hardware design reduces the cost and schedule time associated with development and qualification of new hardware designs.

1.1 Purpose

The purpose of this verification plan is to identify all of the environmental tests and analyses, as well as the calibration steps required at the subsystem and system levels to qualify one protoflight HIMSS instrument and to deliver two follow-on instruments.

1.2 Scope

This document establishes the test policies and requirements that control all environmental testing of the HIMSS subsystems and system. It includes test philosophy and objectives, test configurations and an approach to accomplishing the objectives by listing the types of tests required in all environments. It also includes the test documentation required. Deviations from these test sequences require Program Manager approval. Components, i.e., piece parts, level testing is not included in this plan, but it is discussed in the Performance Assurance Implementation Plan, and involves standard procedures for receiving inspection and test on purchased space qualified parts.

1.3 Acronyms List

BAPTA	Bearing and Power Transfer Assembly
BDU	Bus Data Unit
CE	Conducted Emission
CEI	Contract End Item
CPT	Comprehensive Performance Test
CS	Conducted Susceptability
EA	Electrical Assembly
EM	Engineering Model
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
Eos	Earth Observing System
FFT	Full Functional Test
GIIS	General Instrument Interface Specification
GSFC	Goddard Space Flight Center
HIMSS	High Resolution Microwave Spectrometer Sounder
IR	Infra-Red

LFT	Limited Functional Test
LPT	Limited Performance Test
MWA	Momentum Wheel Assembly
RE	Radiated Emission
RS	Radiated Susceptability
SIC	Standard Interface Connector
SPU	Signal Processing Unit
SSM/I	Special Sensor Microwave/Imager
STE	System Test Equipment
TBD	To Be Determined
TBR	To Be Resolved
TBS	To Be Supplied
TV	Thermal Vacuum Test

2. APPLICABLE DOCUMENTS

The following list of documents form a part of this plan to the extent specified herein.

SPECIFICATIONS

Hughes

HIMSS program

TBD	Performance Assurance Implementation Plan
TBD	Verification Specification
TBD	EMC/EMI Design & Implementation Requirements Plan
TBD	Magnetic Control Plan
TBD	Contamination Control Plan
TBD	Hardware Transportation Handling Plan
TBD	CEI Specification

NASA

GSFC S-480-18	Performance Assurance Requirements
GSFC S-480-19	Performance Specifications

Military

MIL-STD-461B	EMI Characteristics, Requirements for Equipment
MIL-STD-462	EMI Characteristics, Measurement of

3. VERIFICATION PHILOSOPHY

3.1 Verification Approach

A low risk, low cost environmental verification program will be performed at unit and instrument level testing. In this approach, very little qualification hardware will be expended in test; rather, flight hardware will be utilized in all verification environmental testing.

Every first article unit is to be tested to protoflight levels unless it has been flight qualified already. This qualification verification program consists of a thermal stress test of TBD temperature cycles to qualification levels, random vibration to prototype levels, a thermal and thermal-vacuum performance test. This approach, which exceeds the NASA requirements, will ensure that the units and spacecraft will meet the mission goals and that the heritage analyses have not overlooked design applications with subtle environmental differences.

Subsequent to the first article all units and the instrument will be acceptance tested. At the unit level, this includes a thermal stress test of 6 thermal cycles to qualification levels plus acceptance level random vibration acceptance level performance testing.

3.2 Environmental Predictions

The environments to which the HIMSS instruments will be exposed through their mission life is the well understood extension heritage of SSM/I. Analytical models of the structural and thermal characteristics of the HIMSS instrument shall be developed. These analytical models will be updated on a continuing basis when additional empirical data become known. The environmental predictions are used for:

- 1) Generating environmental design criteria and restraints
- 2) Defining formal protoflight and flight acceptance test requirements

3.3 Environmental Test Objectives

The principal objectives of the unit/subsystem and system level environmental tests for HIMSS are as follows:

- 1) System Environmental Test Objectives
 - a) Establish confidence that the instrument design will function as required under exposure to flight mission conditions

- b) Establish confidence that the flight instrument quality and workmanship is representative of the quality of design verified by the protoflight system test and will therefore be flight acceptable.
 - c) Evaluate the effect of system interacted environments
- 2) Unit/Subsystem Environmental Test Objectives
 - a) Establish confidence that each unit/subsystem design will function as required, under exposure to all of the environments the hardware will encounter as parts of the instrument
 - b) Establish confidence that the workmanship and quality of each flight unit/subsystem is representative of the protoflight-test-verified design quality and that the hardware will function as required under exposure to flight mission environmental conditions.

3.4 Documentation Requirements

The following plans, procedures, and reports are required to document the environmental verification program.

3.4.1 Verification Specification

A Verification Specification shall be prepared that describes the activities required by this Verification Plan.

For each test activity, the Verification Specification shall include the configuration of the item, objectives, facilities, instrumentation, safety considerations, contamination control, test phases and profiles, necessary functional operations, personnel responsibilities, and requirements for procedures and reports. It shall also include a rationale for retest determination that does not invalidate previous verification activities. When appropriate, the interaction of the test and analysis activity shall be described.

For each analysis activity, the specification shall include objectives, a description of the mathematical model, assumptions on which the models will be based, required output, criteria for assessing the acceptability of the results, the interaction with related test activity, if any, and requirements for reports.

3.4.2 Verification Procedures

For each functional and environmental test activity conducted at the system levels, verification procedures shall be prepared

that describe how each test activity contained in this Verification Plan and the Verification Specification will be implemented.

The procedures shall describe details such as instrumentation monitoring, facility control sequences, test article functions, test parameters, quality control checkpoints, data collection, and reporting requirements. The procedures also shall address safety and contamination control provisions.

3.4.3 Verification Reports

After completion of each unit, subsystem, and system verification activity, a report shall be prepared. For each test activity, the report shall contain, as a minimum, the information described on the sample test report contained in Figure 3-1. For each analysis activity, the report shall describe the degree to which the objectives were accomplished, how well the test data validated, the mathematical model, and other significant results.

In addition, as-run verification procedures, as well as all test and analysis data, shall be retained to be available for review upon request.

3.5 Criteria for Unsatisfactory Performance

Deterioration or any change in performance of any test item that does or could in any manner prevent the item from meeting its functional, operational, or design requirements throughout its mission shall be reason to consider the test item as having failed.

1) Failures - When a failure occurs a determination shall be made as to the feasibility and value of continuing the test to its specified conclusion. If corrective action is taken, the test shall be repeated to the extent necessary to demonstrate that the test item's performance is satisfactory.

2) Failures with Retroactive Effects - If corrective action taken as a result of failure, e.g., redesign of a unit, affects the validity of previously completed tests, prior tests shall be repeated to the extent necessary to demonstrate satisfactory performance.

3) Failure Reporting - Every failure shall be recorded and reported in accordance with HIMSS failure reporting procedures.

VERIFICATION TEST REPORT		
PROJECT _____		
TEST ITEM _____		
MANUFACTURER _____		
SERIAL NUMBER _____		
LEVEL OF ASSEMBLY: <input type="checkbox"/> COMPONENT <input type="checkbox"/> SUBSYSTEM <input type="checkbox"/> PAYLOAD		
TYPE HARDWARE: <input type="checkbox"/> PROTOTYPE <input type="checkbox"/> PROTOFLIGHT <input type="checkbox"/> FLIGHT <input type="checkbox"/> SPARE		
TYPE TEST:		
<input type="checkbox"/> STRUCTURAL LOADS	<input type="checkbox"/> PRESSURE PROFILE	<input type="checkbox"/> THERMAL-VACUUM
<input type="checkbox"/> VIBRATION	<input type="checkbox"/> MASS PROPERTIES	<input type="checkbox"/> THERMAL BALANCE
<input type="checkbox"/> ACOUSTICS	<input type="checkbox"/> ELECTROMAGNETIC COMPATIBILITY	<input type="checkbox"/> THERMAL CYCLING
<input type="checkbox"/> MECHANICAL SHOCK	<input type="checkbox"/> MAGNETIC PROPERTIES	<input type="checkbox"/> TEMPERATURE-HUMIDITY
<input type="checkbox"/> MECHANICAL FUNCTION		<input type="checkbox"/> LEAKAGE
<input type="checkbox"/> MODAL SURVEY		<input type="checkbox"/> COMPREHENSIVE
<input type="checkbox"/> OTHER (EXPLAIN) _____		
VERIFICATION PROCEDURE NO. _____ REV _____ DATE _____		
<input type="checkbox"/> INITIAL TEST		
<input type="checkbox"/> RETEST (<input type="checkbox"/> PARTIAL OR <input type="checkbox"/> FULL; STARTING DATE OF INITIAL TEST _____)		
APPLICABLE VERIFICATION PLAN: _____		
FACILITY DESCRIPTION: _____		
LOCATION _____		
TEST LOG REFERENCE: _____		
COMMENTS:		
SIGNATURE:		
QUALITY ASSURANCE REPRESENTATIVE: _____		DATE _____
COGNIZANT ENGINEER FOR TEST ITEM: _____		DATE _____

FIGURE 3-1. SAMPLE TEST REPORT

DATE (ADD TIME FOR THERMAL AND TEMPERATURE TESTS)	NOTE BEGINNING AND END OF ACTUAL ACTIVITY, DEVIATIONS FROM THE PLANNED PROCEDURE, AND DISCREPANCIES IN TEST ITEMS PERFORMANCE. (STATE IF THERE WERE NO DEVIATIONS OR DISCREPANCIES)	MALFUNCTION REPORT NUMBER AND DATE (IF APPLICABLE)
	(USE ADDITIONAL PAPER AS REQUIRED)	

THESE REPORTS SHALL BE COMPLETED AND TRANSMITTED TO THE GSFC TECHNICAL OFFICER OR CONTRACTING OFFICER (AS APPROPRIATE) WITHIN 30 DAYS AFTER THE COMPLETION OF AN ACTIVITY. LEGIBLE, REPRODUCIBLE, HAND-WRITTEN COMPLETED FORMS ARE ACCEPTABLE

THE FORMS SHALL BE SIGNED BY THE QUALITY ASSURANCE REPRESENTATIVE AND THE PERSON RESPONSIBLE FOR THE TEST ITEM OR HIS DESIGNATED REPRESENTATIVE: THE SIGNATURES INDICATE CONCURRENCE THAT THE DATA IS AS ACCURATE AS POSSIBLE GIVEN THE CONSTRAINTS OF TIME IMPOSED BY QUICK-RESPONSE REPORTING

THIS REPORT DOES NOT REPLACE THE NEED FOR MAINTAINING COMPLETE LOGS, RECORDS, ETC.; IT IS INTENDED TO DOCUMENT THE IMPLEMENTATION OF THE VERIFICATION PROGRAM AND TO PROVIDE A MINIMUM AMOUNT OF INFORMATION AS TO THE PERFORMANCE OF THE TEST ITEM

FIGURE 3-1 (CONTINUED). SAMPLE TEST REPORT

4. TEST FACILITIES REQUIREMENTS

4.1 Performance Requirements

The facilities and fixtures used in conducting tests shall be capable of producing and maintaining the required test conditions with the test specimen installed on the apparatus or not operating as specified.

In any major test, facility performance shall be verified prior to the test either by a review of its performance during a test that occurred a short time earlier or by conducting a test with a substitute test item.

4.2 Safety Requirements

The test facility manager shall verify that the test facility and normal operations present no unacceptable hazard to the test item, test and support equipment, or personnel. He shall ensure that facility personnel abide by all applicable OSHA regulations, observe all appropriate industrial safety measures, and follow all requirements for personal protective equipment. He shall ensure that all facility personnel are appropriately trained and qualified for their positions. This training shall include the handling of emergencies by simulating emergency conditions. Analyses, tests, and inspections shall be used to verify that the foregoing requirements are satisfied. Before any test, the test facility manager shall meet with the test conductor and project manager to agree on the degree of residual risk assumed.

4.3 Facility Instrumentation Requirements

Test facilities shall have instruments to verify the environmental conditions generated within the facility. Measurement uncertainties shall not contribute more than 25 percent of the tolerance assigned to each test condition. All facility instrumentation used in support of test or for monitoring environmental conditions shall be current in calibration as evidenced by dated calibration stickers.

4.4 Test Laboratory Ambient Conditions

Laboratory ambient conditions for conducting electrical or mechanical performance tests on the HIMSS instrument or for exposure of the instrument for any reason shall be in accordance with TBD, Contamination Control Plan. The ideal conditions are:

Cleanliness	Class 100,000 (Fed Std 2098)
Temperature	23° ±5°C
Relative Humidity	25 to 60 percent

Barometric Pressure

Local ambient (corrected to 29.92 in Hg if required by performance specifications)

Some unit level hardware may not be degraded by exposure to more relaxed ambient environment conditions. In these cases, the unit may be tested under relaxed ambient conditions, with program office approval. Units which have been exposed to ambient environments outside the tolerance specified must be cleaned prior to being introduced into the laboratory with clean hardware.

The BAPTA shall be protected per TBD, Contamination Control Plan at all times.

4.5 Test Condition Tolerances

The maximum allowable tolerance for test conditions shall be TBR.

4.6 Transportation and Handling Environment

To ensure that environmental conditions resulting from transportation and handling do not impose an unnecessary penalty on the design of the instruments, the shipping and handling environment shall be controlled by specified modes of transportation and handling and by properly designed shipping containers. The controls shall ensure that the environment to which the hardware is exposed is not more severe than that for which the environmental test program is designed. These requirements are defined in TBD, Hardware Transportation Handling Plan.

Items such as shipping containers shall be verified as meeting the design requirements with reasonable certainty of function. Either analysis or test shall be performed to ensure proper function under the environments in which they will be required to operate, e.g., transportation, handling, and storage.

5. VERIFICATION PROGRAMS

5.1 Sensor Development Test Requirements

Even though HIMSS draws its heritage from SSM/I, there are sufficient modifications to the subsystems to warrant the build-up of an Engineering Model (EM), which will verify the design and be the test item for the development of the test procedures and for the STE hardware and software.

5.1.1 Engineering Model Definition

Figure 5.1-1 is a block diagram of the EM. Essentially, the EM is a one channel radiometer, with all subsystems represented. The electronic units are form, fit and function similar to the flight units, except that the parts are not necessarily space qualified, and therefore the EM will not have any environmental tests.

5.1.2 EM Performance Verification Requirements

These performance verification tests are intended to reveal any design deficiencies, but still demonstrate satisfactory performance within allowable tolerances. A full functional test (FFT) shall be developed for the protoflight sensor and used on the EM as a check on the completeness of the test procedure.

This FFT will be described in section 5.2.

5.2 Subsystem Verification Requirements

These subsystems tests are intended to reveal any other design (the ones not discovered in the EM testing) and/or workmanship deficiencies. They are performed at the same level for both, protoflight and flight hardware.

5.2.1 Antenna Subsystem

5.2.1.1 Objectives. The antenna subsystem will be tested to demonstrate mechanical alignment and to determine the radiation characteristics of the feed array coupled with the main reflector, the cold sky reflector, and the hot loads. Success criteria are listed in the CEI specification.

5.2.1.2 Test Item Description. The test item is the complete antenna subsystem, consisting of the reflector, feed, array support ring, hot holds and cold load (cold sky reflector).

5.2.1.3 Approach.

Prior to any range testing of the main reflector/feed array, the main reflector will be mechanically aligned to the feed array.

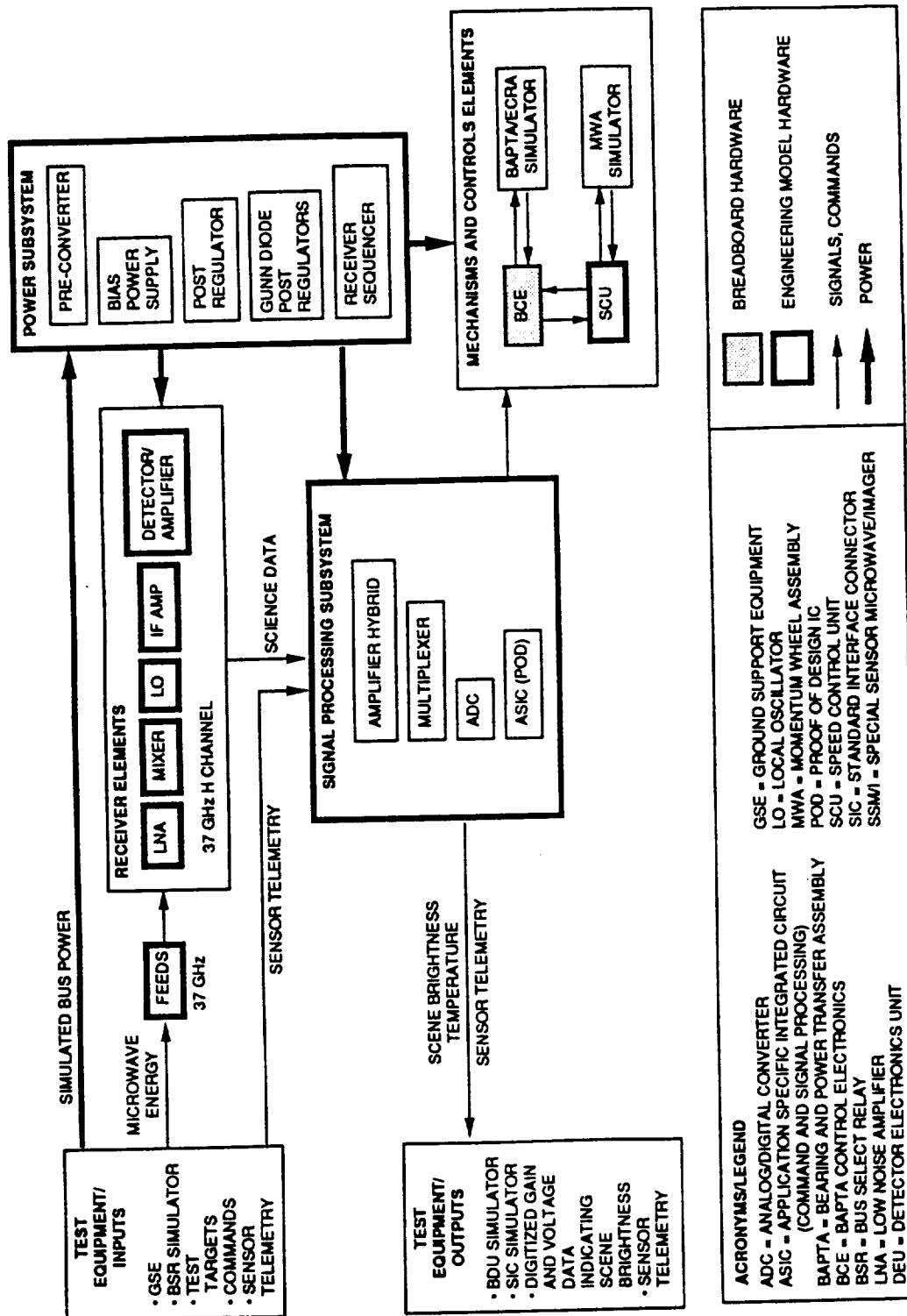


Figure 5.1-1 Engineering Model Block Diagram

Two reference mirrors on the reflector are calibrated with respect to each other and the antenna beam centerline. This calibration data is carried forward to sensor integration and assembly to ensure proper installation alignment of the antenna subsystem. These two sensor mounted mirrors will contain cross hairs for vertical measurements.

Initial testing on the range will consist of focusing the antenna by adjusting the feed array axially, transversely, and rotationally. Focusing is required to balance the sidelobes, maximize the gain, and minimize the cross-polarization. An important constraint on the optimization is that all beams must point within specified limits.

Beam efficiency for the main reflector/feed is calculated from principal polarization and cross-polarization pattern data measured on a TBD foot antenna range using a radiation pattern subassembly. The pattern data will be measured by digitally recording amplitude levels at discrete angular points. The beam efficiency will be determined at the center frequency and at the band edges.

Radiation patterns for the cold reflection/feed system will also be measured. Patterns will be recorded with the feed at the center of the cold reflector and at $\pm 5^\circ$ from the center (sensor sampling angle). The VSWR of the feed array when looking at the cold sky reflector will be measured using swept frequency techniques.

5.2.2 Electrical Assembly Test

5.2.2.1 Objective.

A Full Functional Test (FFT) will be performed before and after environmental exposure of the EA. Limited Functional Tests (LFT) will be performed during the thermal cycling. The definition of these tests is in section 5.2.2.3.

Success criteria are meeting the requirements for noise figure, radiometer Delta T, reference time, the correct command response, and power consumption listed in the CEI specification.

5.2.2.2 Electrical Assembly (EA) Definition

Figure 5.2-1 is a block diagram of the EA. The receiver modules and the electronic units are mounted on a test plate for ease in replacing the modules or units and for ease in debugging any test problems. This configuration of the EA will be thermal cycled, and therefore will have some non-flight instrumentation components and test connectors to monitor the temperatures and performance status of the test items.

5.2.2.3 Approach

The EA test sequence is shown in Figure 5.2-2. The test starts with the initial FFT, continues with 6 thermal cycles, and completes with a final FFT. LFTs are performed during the thermal cycling at the temperature extremes. In the 5th thermal cycle the low temperature will be -35 degrees C, and a cold turn-on will be exercised. Only the power subsystem and the SPU will be turned on; receivers shall not operate below -10 degree C.

The definitions of the FFT and LFT follow:

Full Functional Test (FFT)

The FFT shall be a detailed demonstration that the EA meets the performance and interface requirements at ambient before and after thermal cycling. The measurements made in this test are: noise figure, radiometer Delta T, reference time and command response/power consumption.

Limited Functional Test (LFT)

This test is a short engineering evaluation of the status of the EA at the temperature extremes, during the thermal cycling. The test performed is the command response/power consumption test.

Table 1 shows the tests performed during a FFT and a LFT.

<u>Test Parameter</u>	<u>FFT</u>	<u>LFT</u>
Noise figure	X	
Radiometer Delta T	X	
Reference Time	X	
Command Response/ Power Consumption	X	X

These tests are described below:

Noise Figure

The noise figure of the individual receivers will be measured by switching the input between a hot and cold load and observing the detected video output (video signal monitor).

Radiometer Delta T

Using the temperature data stream from the STE test station, the radiometer will be calibrated by alternately locating a cold and hot load at the receiver input and by computing the radiometric transfer characteristic ($^{\circ}\text{K}/\text{volt}$). Then, with the input looking at a fixed temperature, a large number of data samples will be taken to determine the statistical distribution of the

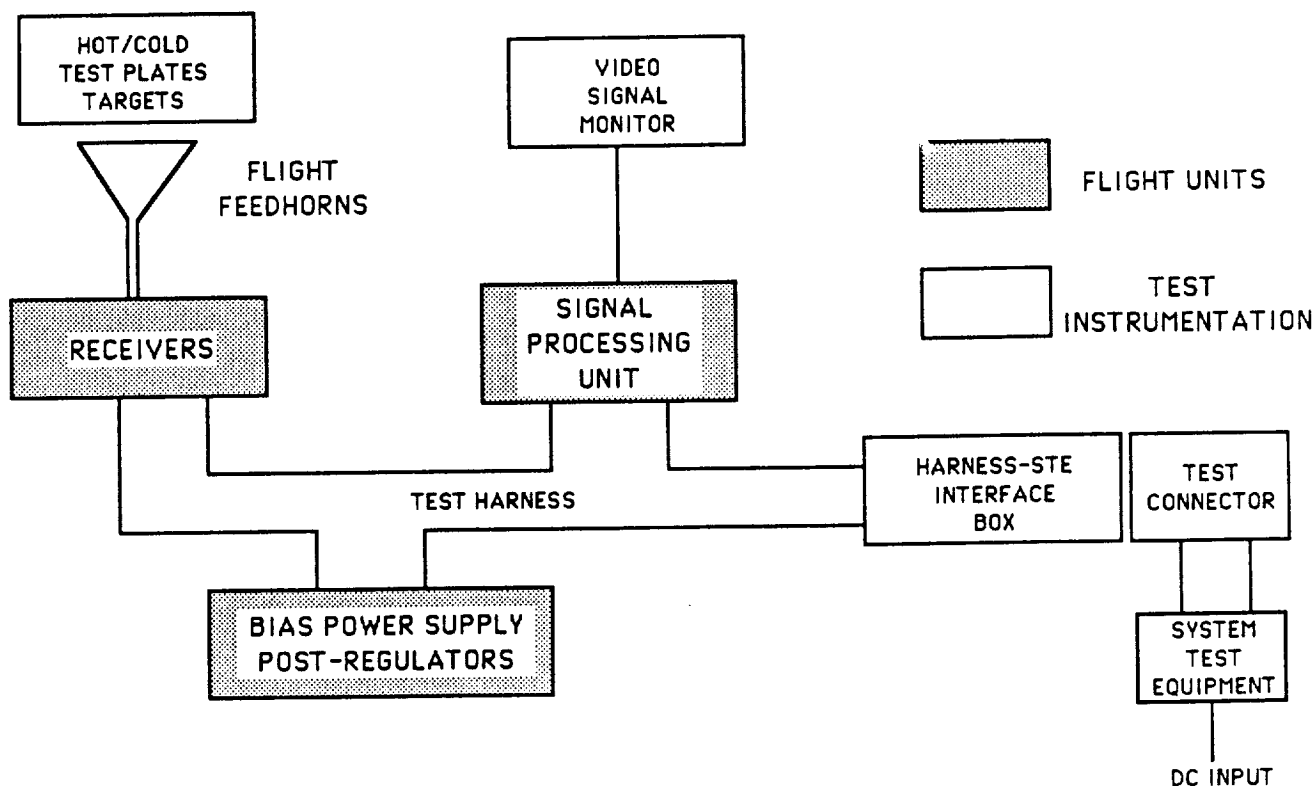


Figure 5.2-1 Electrical Assembly and Test Setup Block Diagram



* LFT PERFORMED AT THE 1ST, 3RD & 5TH
CYCLE TEMPERATURE EXTREMES

FFT - FULL FUNCTIONAL TEST
LFT - LIMITED FUNCTIONAL TEST

Figure 5.2-2 Electrical Assembly Subsystem Test Sequence

measurements. Delta T is then computed from the rms variance determined from the temperature data samples.

Reference Time

TBS

Command Response/Power Consumption

Command signals are given to the electronics through the STE test station. The STE will activate all sensor functions. Power consumption of the electronics assembly will be monitored both through the STE Test Station and with power monitors accessed to the power supplies through a unit test connector.

Thermal Cycling

There shall be 6 thermal cycles, with the 5th cycle designated as the survival cycle. The temperatures limits are -10 and +50 degrees C. A LFT will be performed at the temperature extremes on the first, 3rd and 6th cycle. The cold turn-on shall be demonstrated during the 5th cycle (survival cycle). The low plate temperature for the survival cycle shall be -35 degrees C. During this cycle only the power subsystem and the SPU will be turned on. The receivers shall not be operated at temperatures below -10 degrees C.

5.3 Protoflight Instrument Verification Requirements

5.3.1 Objective

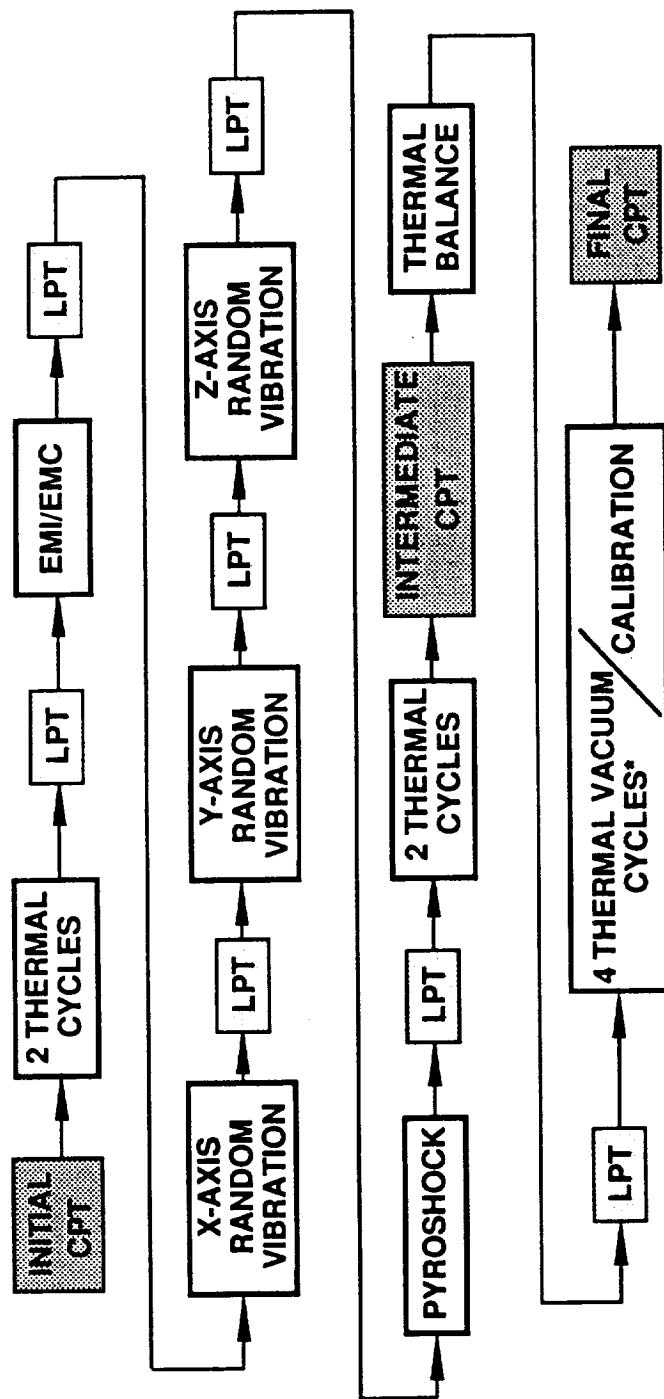
During the protoflight instrument verification tests, all design and performance requirements identified in the CEI Specification, that can be verified at system level, shall be verified. This protoflight verification program has been selected to give confidence that the HIMSS instrument shall perform satisfactorily, as designed, in all environments.

The protoflight instrument qualification sequence is shown in Figure 5.3-1. This sequence may be changed with program manager concurrence.

5.3.2 Test Configuration

The instrument configuration may differ between tests; performance test targets differ from the TV test/calibration targets, sensor is spinning in part of the performance test, and its is stowed for the vibration and pyroshock tests.

Table 5.3-1 is a matrix of the qualification tests and the instrument configuration.



*A LPT IS PERFORMED AT EACH TEMPERATURE EXTREME

CPT: COMPREHENSIVE PERFORMANCE TEST

LPT: LIMITED PERFORMANCE TEST

Figure 5.3-1 Protoflight Instrument Verification Sequence.
This sequence is preceded by Magnetic and Momentum Compensation and Spin Balance/Mass Properties Test.

Table 5.3-1

<u>Test</u>	<u>Configuration</u>
Performance	Full-up, spinning and non-spinning
EMI/EMC	Full-up, spinning
Vibration	Stowed
Pyroshock	Stowed
Thermal Balance	TV
Thermal Vacuum/ Calibration	TV

A description of possible configurations follows:

Stowed

In this configuration the complete sensor, preconverter, MWA, and the GE units are mounted on the PSS, exactly in a launch configuration. The reflector is stowed and tied down. All installations shall be flight level.

Full-up

In this configuration the complete sensor is mounted on the PSP. The preconverter and the MWA are mounted nearby, approximate flight configuration distance, and electrically connected to the sensor, with the flight harness. This configuration can be spinning or non-spinning, as required by the procedure.

TV Configuration

The TV configuration is a subset of the full-up configuration. The main and cold sky reflectors are replaced with specially designed targets, held in place above the sensor by the TV test fixture. The preconverter and the MWA are electrically connected, located near the sensor.

5.3.3 Approach

The test sequence, shown in Figure 5.3-1, shows all the tests to be performed on the protoflight instrument, and the preferable order. The details for each of these tests follow.

5.3.3.1 Electrical Function Test Requirements

The comprehensive performance test (CPT) is a combination of tests that verify all the electrical functions and interfaces. The limited performance test (LPT) is a subset of the CPT to be performed as a health check on the sensor before and after an environmental test.

Table 5.3-2 shows the tests that make up the CPT and LPT.

Table 5.3-2

<u>Test</u>	<u>CPT</u>	<u>LPT</u>
System test equipment (STE) check*	X	X
Noise Figure	X	
Radiometer Delta T	X	
Reference Time	X	
Command Response	X	X
Power Consumption	X	X
Scan Accuracy	X	
Deployment	X	

* performed after the STE was moved to a new location for an instrument test.

5.3.3.2 Structural and Mechanical Requirements

These tests and the interdependent analyses, are designed to demonstrate compliance with the structural and mechanical requirements stated in the GIIS.

Modal Survey Test

The HIMSS protoflight instrument shall be subjected to a modal survey to define the dynamic response characteristics (mode shapes, resonant frequencies, and modal dumping) of the instrument up to 100 Hz. In general, the boundary conditions under which the hardware is supported during the test duplicates those expected during launch. When that is not feasible, other boundary conditions are employed and the upper frequency limit of the test is adjusted accordingly. The effects of interface flexibilities should be considered when other than normal boundary conditions are used.

The results of the modal survey are required to identify any inaccuracies in the mathematical modal used in the payload analysis program so that modifications can be made if needed. Such an experimental verification is needed because a degree of uncertainty exists in unverified models owing to assumptions inherent in the modeling process. These lead to uncertainties in the results of the flight dynamic loads analysis, thereby reducing confidence in the accuracy of the set of limit loads derived therefrom.

Any of several test methods may be used to perform the modal survey. They include the use of sinusoidal dwell techniques with either single or multiple shakes or Fast-Fourier-Transform (FFT) processing techniques in which the test item is excited at a single point with random vibration or transient forcing functions.

Vibration Test

The protoflight HIMSS instrument shall be attached to the test equipment by a rigid fixture. The mounting should simulate insofar as practicable the mounting on the observatory with particular attention paid to duplicating the actual mounting contact area between the instrument and the observatory. In mating the instrument to the fixture, flight-type mounting and fasteners shall be used. The instrument under test shall be subjected to random vibration along each of three mutually perpendicular axes.

For the purpose of controlling vibration, calibrated accelerometer(s) shall be attached rigidly on the test fixture near the fixture-test item interface and aligned with the axis of applied vibration. Accelerometers used for control are selected from those types shown to have a low base-strain sensitivity.

Before and after the random vibration exposure, the test item shall be examined and functionally tested. Between axes of vibration, the instrument shall be functionally tested with a LPT.

With the instrument mounted on the vibrator, the excitation spectrum, as measured by the control accelerometer(s), shall be equalized such that the overall rms level is within ± 10 percent of that specified. The power spectral density should be within ± 3 dB of the specified levels everywhere in the frequency band when analyzed with a spectrum analyzer that has filter bandwidths which do not exceed 25 Hz below 1200 Hz or 100 Hz above 1200 Hz.

Pyroshock Test

The pyroshock test requirements shall be satisfied by firing the antenna and the Marman clamp pyrotechnics. These tests shall be performed twice, testing the performance of the instrument with a LPT before and after each firing.

Mass Properties Test

The weight, mass center location, moments of inertia, and products of inertia shall be determined for all configuration as required to evaluate and predict flight performance. This test is performed on the full-up instrument before the start of system tests.

Spin Balance Test

TBS.

Momentum Compensation Test

TBS.

5.3.3.3 Electromagnetic Compatibility (EMC) Requirements

Electromagnetic compatibility of the protoflight instrument shall be verified by test using the requirements of MIL-STD-461 B and 462 as guides. The tests required by the PAR document are listed below:

CE Dc power leads

RE E fields

RE Spurious

CS power lines

CS Power lines transients

RS E field

RS magnetic field susceptibility

Magnetic properties*

* Each instrument shall have a magnetic compensation test. The resulting magnetic field of the instrument is minimized during the test, by placing magnets inside the instrument to cancel the existing magnetic field.

5.3.3.4 Thermal and Vacuum Requirements

Thermal Cycling

The protoflight instrument shall have two thermal cycling test phases. The first one is immediately after completing the initial CPT. The purpose of this test is to eliminate any units or components that might have manufacturing deficiencies that were not discovered at the unit or subsystem level test. The second set of thermal cycling occurs after the vibration and pyroshock tests, and its purpose is to discover any other design deficiencies that might have been disturbed by these two tests.

The test configuration is a full-up sensor, non-spinning. The temperature extremes are -10 (TBR) and ± 40 (TBR) degrees C. LPT shall be performed at the temperature extremes.

Thermal Vacuum Test (TV) Requirements

The HIMSS protoflight instrument shall be tested in a thermal-vacuum environment to verify proper operation of the instrument in a simulated space environment and to calibrate it. The TV consists of four thermal cycles, the last one serving as the calibration test. During calibration the sensor temperature is increased in three steps, with a complete calibration being performed at each one of these temperature plateaus.

The test configuration is the TV configuration, spinning (see sec 5.3.2). The temperature extremes are -10 (TBR) and +40 (TBR) degrees C. A LPT shall be preformed at each temperature extreme. A cold turn-on, at the third cold extreme, shall be demonstrated.

Thermal Balance Test

Thermal balance testing shall be performed to validate the analytical thermal models and the performance of the thermal design. It shall be performed in a thermal-vacuum environment with chamber pressures less than or equal to 1.0×10^{-5} Torr. The external thermal loads imposed on the sensor by its environment shall be simulated by infrared (IR) lamp sources and film heaters. The sensor configuration is the same as in TV, spinning.

5.4 Flight Instrument Verification Requirements

5.4.1 Objective

These tests shall verify performance of previously qualified hardware. The acceptance test sequence is shown in Figure 5.4-1. This sequence may be changed with program manager concurrence.

5.4.2 Test Configuration

The flight hardware shall have the same configurations as discussed in 5.3.2 for the protoflight instrument.

5.4.3 Approach

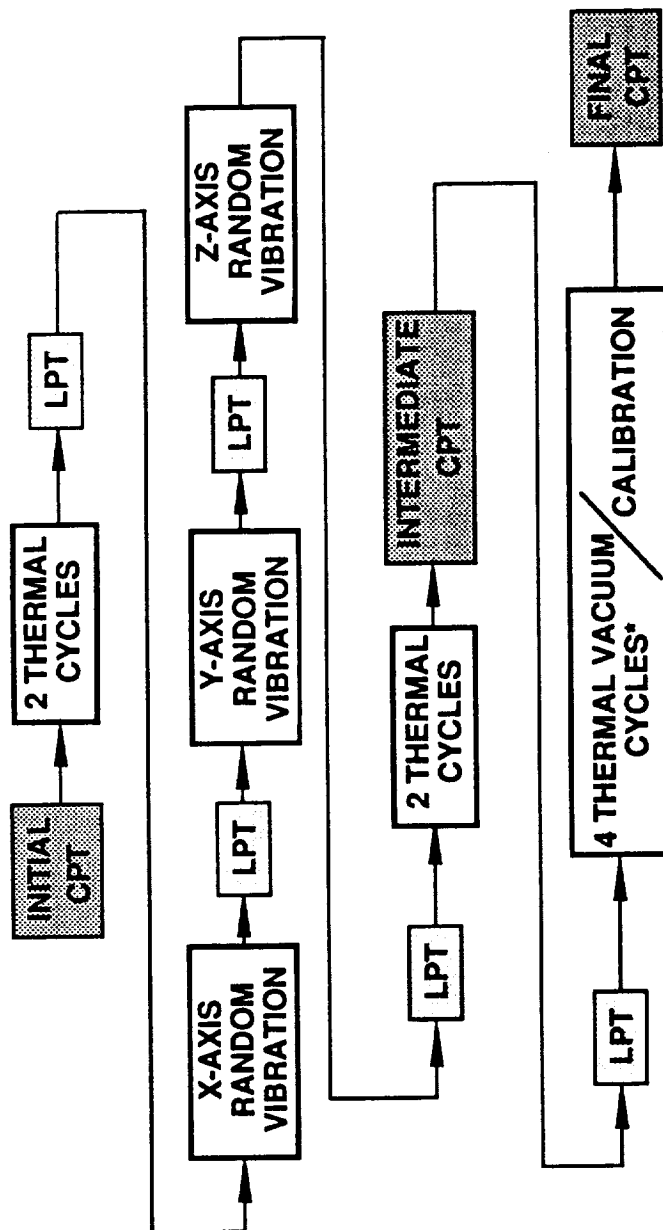
The flight instrument verification tests are a subset of the protoflight instrument verification tests. The deleted tests from this acceptance program are:

- Modal Survey Test
- Pyroshock Test
- Electromagnetic Compatibility Test
- Thermal Balance Test

All other tests are performed similarly to the protoflight tests, except the vibration test levels. These levels are 3dB lower in the acceptance tests than in the protoflight tests. The success criteria are also the same as in the protoflight tests.

5.5 HIMSS - Observatory Compatibility Tests

A compatibility test shall be performed between the HIMSS signal processing subsystem and the observatory's BDU and SIC to verify the correct signal and data interfaces. The SPU shall be the engineering model and performed early in the program to allow sufficient time for any necessary changes resulting from this test.



*A LPT IS PERFORMED AT EACH TEMPERATURE EXTREME

CPT: COMPREHENSIVE PERFORMANCE TEST

LPT: LIMITED PERFORMANCE TEST

Figure 5.4-1 Flight Instrument Verification Test Sequence.
Magnetic Compensation and Momentum Compensation and
Spin Balance/Mass Properties Test precede this sequence.

Figure 5.5-1 shows the compatibility test configuration.

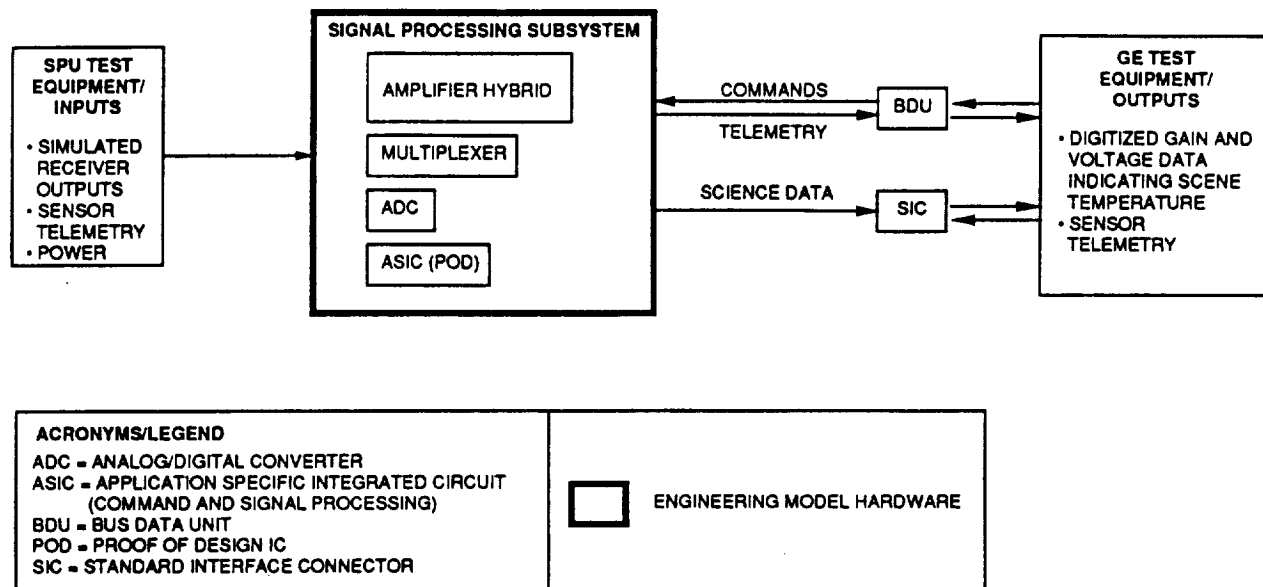


Figure 5.5-1 Compatability Test Configuration to be performed at the Payload Integrator's facility.

5.0 CONTRACT END ITEM (CEI) SPECIFICATION - PRELIMINARY

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HIMSS CONTRACT END ITEM DETAIL SPECIFICATION

1. SCOPE

This part of this specification establishes the requirements of performance, design, and verification of one series of equipment identified as the High Resolution Microwave Spectrometer Sounder (HIMSS) with contract end item number TBS. This CEI provides multispectral microwave remote sensing data to support the mission objectives of the Earth Observing System (Eos) program.

2. APPLICABLE DOCUMENTS

The following documents form a part of this specification to the extent specified herein. Specifications in this document shall supersede any disagreements found between it and any of the documents referenced below.

	NASA Polar Orbiting Platform (NPOP-1) General Payload Interface Specification
DOD-E-8783C	Elec Equipment, Aerospace Extended Environment, General Spec For
GSFC-415-EOS-00004	Earth Observing System Performance Assurance Requirements for General Instruments
JSC 30237	Space Station EMI/EMC Requirements
JSC 30425	Space Station Natural Environment for Design
MIL-HDBK-217	Reliability Prediction of Electronic Equipment (All)
MIL-STD-143	Military Standards and Specifications, Order of Preference for the Selection of
MIL-STD-461	Electromagnetic Interference Characteristics, Requirements for Equipment
MIL-STD-462	Electromagnetic Interference Characteristics, Measurement of
MIL-STD-975	NASA Standard Electrical, Electronic, and Electromechanical Parts List
MIL-STD-1541	Electromagnetic Compatibility Requirements for Space Systems (All)
MIL-STD-1524	System Safety Program for Space and Missile Systems
WSMR 127-1	Western Space and Missile Range Safety Requirements

3. REQUIREMENTS

3.1 Definition

3.1.1 General Description

The HIMSS is a conically scanning, multichannel, passive total power microwave radiometer for continuous operation on the NASA Eos Polar Orbiting Platform (NPOP-1). The following subparagraphs describe each of the five major subsystems which, together, make up the HIMSS system.

3.1.1.1 Antenna Subsystem

This subsystem consists of:

1. A graphite-epoxy composite reflector of at least 2 meter aperture.
2. A set of conical feed horns through which the reflected radiation passes.
3. A cold sky reflector (cold load) and warm blackbody reference (warm load) for calibration.

3.1.1.2 Receiver Subsystem

This subsystem consists of the waveguides, mixers, local oscillators (LO's), amplifiers, and detectors necessary to convert the energy incident on the feedhorns to a voltage for each channel.

3.1.1.3 Signal Processing Subsystem

This subsystem consists of:

1. The electronics required to process the voltage outputs from the receivers and format these data in a manner suitable for transmission to the Payload Data Management System (DMS).
2. Circuitry to control the timing of the integration periods for each channel and ensure accurate coregistration of footprints.
3. Circuitry to acquire and multiplex all sensor telemetry and to process commands for the instrument.

3.1.1.4 Power Supply Subsystem

This subsystem consists of the power supply, which converts the 120V Eos platform supply voltage to the various voltages required by the HIMSS sensor. The power supply subsystem also contains

regulators to ensure low-ripple supply voltages and components to isolate the power-consuming circuitry from the supply lines. A sequencing circuit ensures the proper application of power to the receiver components.

3.1.1.5 Structures, Mechanisms, and Control Subsystem

This subsystem consists of:

1. The physical structure of the HIMSS, including the HIMSS outer housing, internal equipment shelves, and the truss by which the HIMSS is mounted to the Eos platform.
2. The antenna support structure and deployment mechanism (ADM).
3. The Bearing and Power Transfer Assembly (BAPTA), which provides the rotating mechanical and electrical interface between the spinning and despun (fixed) sections of the instrument.
4. The BAPTA motor, which supplies the torque for rotation of the spun section.
5. The BAPTA Control Electronics (BCE), which regulate the BAPTA motor spin rate.
6. The Momentum Wheel Assembly (MWA), which compensates for the effect of the momentum of the spun section on the Eos platform.
7. The heaters and blankets used for thermal control of the HIMSS.

3.1.2 Mission

The mission of the HIMSS is to generate multispectral microwave remote sensing data with sufficient accuracy and coverage to support the scientific objectives of the Eos program. Specific performance requirements to succeed in this mission have been established by Marshall Space Flight Center. The HIMSS shall be designed to meet these requirements (discussed in detail in 3.2.1).

3.1.3 Operational Concepts

3.1.3.1 Storage

After fabrication, the HIMSS will be manually in stowed configuration and secured in its storage/shipping container. While in storage, the instrument may be periodically removed from the storage container, powered up, and proper functioning verified.

3.1.3.2 Integration

The integration of the HIMSS sensor and Eos platform will take place at the Platform Integrator's facilities and will be performed by Platform Integrator personnel. The HIMSS, while in its stowed configuration, will be attached to its truss and the truss/sensor assembly attached to the Platform.

3.1.3.3 Launch and Orbit Insertion

After integration, the HIMSS/NPOP combination will be inserted into a 705 km polar sun-synchronous orbit by a Titan IV launch vehicle. During the entire launch process, the HIMSS will remain in stowed configuration.

3.1.3.4 On-orbit Pre-deployment Phase

Once inserted into orbit, various equipment aboard the Eos platform will be deployed, activated, and checked out. During this time, the HIMSS will remain in stowed configuration, and heaters will maintain the temperature within a suitable range for deployment and turn-on.

3.1.3.5 Deployment

Deployment of the HIMSS takes place in several steps. First, the antenna is released from its stowed position by the firing of a pyrotechnic pin-pulling squib. A spring mechanism rotates the antenna support structure until it is locked in place. Power is applied to the Signal Processing Unit (SPU), BCE, and MWA, and the warm-up heaters are powered up. Next, the BCE motor driver is turned on, and the MWA is commanded to begin spinning. Once the MWA rotation rate exceeds a preset threshold, the sensor BAPTA motor begins to spin at the same rate. After the rotation rate of the HIMSS and MWA reach operational speed, the sensor transfers to a position loop, which maintain the HIMSS and MWA in proper synchronization. Finally, the survival and warm-up heaters are turned off, the receivers are powered up, and data begins flowing to the Platform.

3.1.3.6 On-orbit Operation

In normal operation, the spun section of the HIMSS shall rotate at approximately 40 rpm. The torque for the rotation is provided by the BAPTA motor, and the angular velocity is regulated by the BCE. For 140 degrees active angle of each spin cycle, the sensor field-of-view will point towards the Earth, and microwave radiation emitted by the Earth will be reflected into the feed horns. This energy is converted into a digitized voltage, which is then sent to the DMS (Payload Data Management System) for transmission in the downlink data stream. Once in each spin cycle, the reflector-feed horn path will be interrupted by warm and cold load calibration

reference targets, each covering about 10 degrees of the total rotation. The warm load reference, which will closely approximate a blackbody, will operate between temperatures of 295 K and 310 K. The cold load reference, which reflects deep space, will appear to the sensor to have a temperature of approximately 3 K. Approximately five temperature measurements of each reference load will be made during each spin cycle, and these will be incorporated into the data stream along with the Earth observations to be used later for determination of a calibration slope, which will in turn be used for conversion of the digitized voltages into calibrated brightness temperatures.

3.1.4 Organizational and Management Relationships

TBD

3.1.5 Systems Engineering Requirements

TBD

3.1.6 Government Furnished Property List

TBD

3.1.7 Critical Components

For critical applications, parts shall be selected for use in the order shown below and shall be identified on the respective parts identification lists as being used in a critical application. Critical applications are defined as part applications in circuits or assemblies whose failure, without regard to redundancy, would be critical or catastrophic. The order of selection shall be:

1. Standard Grade 1 parts.

2. Nonstandard parts specified to requirements similar to those for the nearest standard Grade 1 part. If there is a standard part listed in MIL-STD-975, a nonstandard part shall not be used.

3.1.7.1 Engineering Critical Components List

TBD

3.1.7.2 Logistics Critical Components List

TBD

3.2 Characteristics

3.2.1 Performance

3.2.1.1 General Performance

3.2.1.1.1 Scan Pattern

The HIMSS shall have a conical scan pattern with a viewing angle of 46 ± 1 degrees from the vertical spin axis. The HIMSS scan shall be continuous with a scan period of 1.48 seconds (approximately 40 rpm).

3.2.1.1.2 Scan Accuracy

The HIMSS scan position shall be known to within 0.3 degrees along the scan direction and within 0.2 degrees in the cross scan direction with respect to the sensor mounting plate.

3.2.1.1.3 Active Scan Angle

The HIMSS shall collect data over an angle ± 70 degrees from the direction of the Platform velocity vector.

3.2.1.1.4 Calibration

Calibration of the HIMSS with a cold sky and warm load shall be performed every scan. The cold sky calibration errors due to the earth's and sun's influence shall not exceed 0.1 degrees of brightness temperature. Hot calibration errors due to the warm load reflections shall not exceed 0.1 degrees of brightness temperature. The calibration integration time shall be at least four times the longest integration time of the earth observations.

3.2.1.1.5 Radiometric Performance

HIMSS radiometric performance shall be as listed in Table 3-1.

Table 3-1
HIMSS Radiometric Performance

Channel Number	Channel Frequency (GHz)	Maximum Channel Bandwidth (MHz)	Polar-ization	Temp Acc. (K)	Temp Res. (K)	Spatial Res. (km) *	Notes
1	90.0	1500	V	1.5	0.7	5	A
2	90.0	1500	H	1.5	0.7	5	A
3	90.0	1500	V	1.5	0.7	5	A
4	90.0	1500	H	1.5	0.7	5	A
5	37.0	1000	V	1.5	0.4	10	B
6	37.0	1000	H	1.5	0.4	10	B
7	37.0	1000	V	1.5	0.4	10	B
8	37.0	1000	H	1.5	0.4	10	B
9	21.0	500	V	1.5	0.4	17	
10	21.0	500	H	1.5	0.4	17	
11	18.0	500	V	1.5	0.4	17	
12	18.0	500	H	1.5	0.4	17	
13	10.65	400	V	1.5	0.3	31	C
14	10.65	400	H	1.5	0.3	31	C
15-17	6.63	170	V	1.5	0.3	50	C,D
18-20	6.63	170	H	1.5	0.3	50	C,D

Notes:

A - Channels 1 and 2 shall be separated from channels 3 and 4 by one 3 dB beamwidth in the along track direction. Two 90 GHz feedhorns will therefore be provided.

B - 37 GHz channels have two feedhorns to allow Nyquist sampling.

C - Temperature sensitivity for these channels is for an assumed scene temperature of 150 K vs. 300 K for all other channels.

D - The 3 170 MHz channels are contiguous. Sensitivity of 0.3 K applies to a 340 MHz bandwidth.

* - Spatial resolutions refer to the major axis of the 3 dB beamwidth projected on the surface of the earth.

3.2.1.1.6 Antenna Performance

3.2.1.1.6.1 Feedhorn Spillover Pattern

The portion of the feedhorn pattern that is not subtended by the main reflector shall not exceed 2 percent of the total normalized feedhorn gain.

3.2.1.1.6.2 Beam Efficiency

The HIMSS beam efficiency shall be greater than or equal to 91% for all channels. The beam efficiency is averaged over the entire bandwidth of the channel and is defined as follows:

$$\text{Beam Eff}(\%) = \frac{\text{Antenna Power [2.5*(3dB beamwidth)]}}{\text{Total Ant Power + Cross Pol Power}} * \text{FPR} * 100$$

where

$$\text{FPR (Feed Power Ratio)} = \frac{\text{Feed Power Intercepting Reflector}}{\text{Total Feed Power}}$$

The HIMSS extended beam efficiency, as defined below, shall be greater than or equal to 96% for all channels.

$$\text{Ext Beam Eff}(\%) = \frac{\text{Antenna Power [7.5*(3dB beamwidth)]}}{\text{Total Ant Power + Cross Pol Power}} * \text{FPR} * 100$$

The far sidelobe power as defined below shall not exceed 0.2% with a goal of 0.1% at 6.6 and 10.7 GHz.

$$\text{Far Sidelobe Power} = \text{Total Power} - (7.5)*(3\text{dB beamwidth})$$

The total spillover power, which is defined as the sum of the feed spillover and the far sidelobe power from cold space, shall not exceed 4%.

3.2.1.1.6.3 Cross-Polarization

The ratio of the total cross-polarization power to the total co-polarization power for any channel shall not exceed 1%.

3.2.1.1.6.4 Beam Center Coregistration

The beam center coregistration of the HIMSS shall be, as a goal, less than 3 km among all frequencies except 90 GHz. If this goal cannot be met, then the beam center coregistration shall be less than 3 km between the 6.6 and 10.7 GHz channels, and less than 3 km between toe 18, 21, and 37 GHz channels.

3.2.1.1.7 Receiver Type

The receivers shall be of the direct amplification type or of the heterodyne type provided a small rejection band is included at the local oscillator frequency to reduce noise.

3.2.1.1.8 Video Data Processing

Video data from the 20 individual channels shall be digitized and multiplexed into a single data stream. These data, together with calibration and sensor telemetry (3.2.1.1.9) shall be transferred to the platform DMS at a TBD rate. Provision shall be made for storing in the instrument data up to 2 (TBR) scans before transfer to the DMS. Specific details of the interfaces can be found in 3.6.2.1.4.

3.2.1.1.9 Telemetry

The HIMSS shall generate the telemetry listed in Table 3-2. All telemetry shall be multiplexed into the video data and transferred to the platform DMS. Special telemetry indicated in table 3-2 shall also be sent directly to the spacecraft.

Table 3-2
HIMSS Telemetry (Preliminary)

Description	From	To	Type	Function
Antenna Deployment Angle *	ADM	SPU	Analog	Output of Pot on the ADM
Motor ON	BCE	SPU	Digital	Verifies the "Motor ON" command
Warm-up heater ON	PS	SPU	Digital	Verifies the "Heater ON" command
Receiver ON	PS	SPU	Digital	Verifies the "Receiver ON" command
SPU Temperature	SPU	SPU	Analog	Unit temperature
BCE Temperature	BCE	SPU	Analog	Unit temperature
PS Temperature (2)	PS	SPU	Analog	Unit temperature
Receiver Temp (2)	PS	SPU	Analog	Unit temperature
BAPTA Temperature **	BCE	SPU	Analog	Unit temperature
MWA Temperature (2)	MWA	S/C	Analog	Unit temperature
Sensor Current **	PS	SPU	Analog	Total sensor current
Momentum unbalance	BCE	SPU	Analog	Difference between MW rate and BAPTA motor speed
Warm Load Temp(6) * ***	LOAD	SPU	Analog	Calibration load temperature

Notes:

- * The conditioning of these signals is done by the SPU
- ** Telemetry to be sent in the data stream and to the spacecraft
- *** Precision platinum temperature sensors

3.2.2 Physical

3.2.2.1 Mass

The HIMSS shall have a mass of no more than 130 kilograms.

3.2.2.2 Angular Momentum

The HIMSS shall have a residual angular momentum of no more than 0.1 Newton-meter-second.

3.2.2.3 Torque Disturbances

The static imbalance for the HIMSS sensor shall not exceed tbd in-lbm and the dynamic imbalance shall not exceed TBD lbm-in².

3.2.2.4 Dimensional and Volume Limitations

TBD

3.2.3 Reliability

The components selected for the HIMSS shall have proven reliability on other space systems or they will be proven during HIMSS development tests to ensure a high probability of mission survival. The HIMSS shall have a reliability of no less than 0.7 throughout its entire operational life of 5 years on orbit. Estimation and analysis of HIMSS reliability shall be based on data and methods of MIL-HDBK-217.

3.2.4 Maintainability

The HIMSS design shall provide for accessibility and interchangeability of items during factory assembly, testing, and launch preparation. Wherever possible, the removal of an item shall not require the removal of adjacent items. The provisions for subsystem servicing and testing after equipment integration within the HIMSS shall be so arranged as to minimize the disturbance to other subsystems. Connection points required for the functional checkout of the HIMSS shall be easily accessible from the outside.

3.2.5 Operational Availability

The HIMSS shall be designed to operate in the specified orbit and meet all applicable performance specifications for at least 5 years.

3.2.6 Safety

The HIMSS shall be designed to minimize any danger to ground

personnel before launch, as well as to the launch vehicle during launch and deployment. Special handling fixtures will be designed for handling components that need protection due to their shape or fragility. Standard satellite test and safety practices will be observed.

3.2.6.1 Pyrotechnic Device Safety

Premature activation of the HIMSS squibs will be prevented by requiring two sequential commands for firing. Standard NASA squibs will be used. To eliminate the possibility of stray electrical charges from firing the squibs, the connectors carrying the squib ignition signals will be designed to provide an RF shield. In addition, a bleed resistor will be placed in each firing circuit to drain off any accumulated static charges.

3.2.6.2 System Safety Program

Hughes shall plan and conduct a system safety program for the HIMSS instrument as specified in GSFC-415-EOS-00004 (Earth Observing System Performance Assurance Requirements for General Instruments) that accomplishes the following:

- a. Provides for the identification and control of hazards to personnel, facilities, support equipment, and flight systems during all stages of HIMSS development. The system safety program shall also address any hazards that may affect the Eos platform or the launch vehicle.
- b. Satisfies the applicable guidelines, constraints and requirements specified by WSMCR 127-1 (Western Space and Missile Center Range Safety Requirements) and MIL-STD-1574 (System Safety Program for Space and Missile Systems).
- c. Interfaces effectively with the industrial safety requirements of the HIMSS contract and existing Hughes safety policies, procedures, and guidelines.

3.2.6.3 Documentation

Hughes shall submit to GSFC the following documentation as specified in GSFC-415-EOS-00004:

- a. A System Safety Implementation Plan
- b. A safety compliance data package for the HIMSS which meets the requirements of WSMCR 127-1 for an "Accident Risk Assessment Report". The content of the package shall be appropriate to the phase of the program at the time of delivery.

3.2.7 Environment

The HIMSS sensor shall be designed to perform to specification after exposure to the environments listed below, including up to five years of storage, any portion of which may occur either before or after spacecraft integration at the Platform Integrator's facilities, at the contractor's facility, or at the launch site.

3.2.7.1 Natural

3.2.7.1.1 Radiation

The HIMSS shall be capable of operating within specifications over its design lifetime in the trapped radiation environment encountered in the 705 km Platform orbit, as specified in JSC 30425 (Space Station Program Natural Environment for Design). Shielding will be incorporated into the HIMSS design to ensure that the expected radiation damage to electronic components does not exceed worst-case device sensitivities. The assessment of radiation effects on the HIMSS will be performed using a design margin of two for a 5 year design life. To account for the alpha particle flux, the expected proton count will be doubled.

3.2.7.1.2 Cosmic Rays

The HIMSS shall be capable of withstanding a single event upset (SEU) induced by cosmic rays.

3.2.7.1.3 Atomic Oxygen

The HIMSS shall be capable of meeting its requirements over its design life in the atomic oxygen environment (as specified in JSC 30425) found at the 705 km Platform orbit.

3.2.7.1.4 Solar Illumination

The HIMSS shall perform within specification when exposed to solar illumination cycles and the associated earth, moon, and space thermal loads (as specified in TBD) from the 705 km sun-synchronous Platform orbit.

3.2.7.1.5 Magnetic Field

The HIMSS shall meet all requirements following exposure to a TBD gauss field with instrument power off. The HIMSS shall not suffer any permanent damage when exposed to a TBD gauss field with instrument power on. The HIMSS shall operate satisfactorily in the expected ambient magnetic field, consisting of the Earth's field (0.15 to 0.5 gauss), the field produced by neighboring instruments (0.1 gauss maximum), and the magnetic field (TBS gauss maximum) produced by the Platform magnetic torquers.

3.2.7.1.6 Operational Thermal Environment

The HIMSS shall maintain its internal temperature, via the use of Multilayer Insulation (MLI) and various heaters, within the allowable extremes for the BAPTA in the expected thermal environment (as specified in TBD) at the Platform altitude of 705 km.

3.2.7.2 Induced

3.2.7.2.1 ELV Environment

The HIMSS shall be capable of withstanding all of the loads (vibration, temperature, etc.) imposed on it by the Titan IV launch vehicle during the launch. The launch loads are TBS.

3.2.7.2.2 Materials Outgassing

The HIMSS shall be capable of performing within specification in the environment defined by the NPOP-1 General Payload Interface Specification, Section 9.4.3.2.

3.2.7.2.3 Electromagnetic Interference (EMI) and Electromagnetic Compatibility (EMC)

The HIMSS design shall satisfy MIL-STD-1541 (Electromagnetic Compatibility Requirements for Space Systems).

3.2.8 Transportability/Transportation

The HIMSS shall be designed to withstand all conditions that may be normally encountered while transporting it from the contractor's facilities to NASA storage and/or launch facilities. A custom shipping/storage container shall be provided to protect the HIMSS while in transit.

3.2.9 Storage

The shipping/storage container provided for the HIMSS shall protect it from any environmental conditions that may be normally encountered while in storage up to a maximum duration of TBD years. The HIMSS, while in its shipping/storage container, shall withstand temperatures from TBD to TBD and humidity from TBD to TBD.

3.3 Design and Construction Standards

3.3.1 Selection of Specifications and Standards

All materials, parts and processes shall be defined by standards and specifications, selected from those of Government, industry, and contractor in accordance with MIL-STD-143. Rationale for the selection of contractor specifications and standards over existing higher order or precedence standards and specifications shall be

compiled and maintained for historical record. This rationale shall include an identification of each higher order or precedence specification or standard examined and state why each was unacceptable. For purposes of this order or precedence, commercial materials, parts and processes shall be considered equivalent to contractor standards.

3.3.2 General

TBD

3.3.3 Aeronautical

TBD

3.3.4 Civil

Not applicable

3.3.5 Electrical

TBD

3.3.6 Mechanical

TBD

3.3.7 Nuclear

Not applicable

3.3.8 Materials

Materials shall be selected and tested in accordance with GSFC-415-EOS-00004 and the NPOP-1 General Payload Interface Specification and all specifications referenced therein.

3.3.9 Contamination Control

The HIMSS design shall provide for minimization of contamination from external sources before, during, and after launch, and for access for removal of pre-launch contamination. Specifically, the HIMSS feed horns shall be equipped with a non-removable cover to prevent the entry of any debris or other contamination.

3.3.10 Coordinate Systems

3.3.10.1 Orbital Coordinates

The orbital coordinate system used in the design of the HIMSS shall be that used for the Platform generally, as follows: The reference geoid will be an ellipsoid with center at the center of mass of the

earth with a mean equatorial radius of 20,926,694 ft (6,378,145 m) and an inverse flattening of 298.25. The ZG axis will be a line through the origin of the orbital coordinate reference and normal to the reference geoid on the near side. ZG will be positive from the spacecraft toward the earth. The YG axis will be normal to the ZG axis and to the instantaneous inertial velocity. The positive YG axis will lie on the anti-sunlit side of the plane formed by the velocity vector and the ZG axis. The XG axis shall complete the right-handed orthogonal basis.

3.3.10.2 Sensor Alignment

An optical cube will be attached to the HIMSS and used to align the instrument to the alignment reference cube on the platform. The maximum error of alignment shall be no more than TBD for each axis.

3.3.10.3 Sensor-relative Coordinates

The sensor-relative coordinate axes for the HIMSS shall be parallel to the axes of the orbital coordinate system, with the Z axis being a line passing through the center of the BAPTA. The cone angle (46 degrees) is defined relative to the positive Z axis, and the scan angle defined relative to the positive X axis with positive and negative scan angles in the +Y and -Y directions, respectively.

3.3.11 Interchangeability and Replaceability

All HIMSS components shall be designed and fabricated for full interchangeability from one instrument to another. Items bearing the same part number or other identification will be functionally and physically interchangeable. No alterations of the item itself or adjoining items will be necessary when a replacement is made except for alignment adjustments.

3.3.12 Identification and Marking

HIMSS components shall be marked for identification. Marking shall include, but not be limited to, the following:

1. Item Name
2. Part Number
3. Serial Number
4. Manufacturer
5. Actual Weight

3.3.13 Workmanship

Workmanship standards intended to be used on flight models will also be used on the qualification model. Precautions will be taken during manufacture to maintain the design integrity. Workmanship standards will conform to DOD-E-8983C.

3.3.14 Human Performance/Human Engineering

Not Applicable

3.4 Logistics

3.4.1 Maintenance

Routine maintenance of the HIMSS instrument is not required. Provision for facilitating refurbishment and repair during testing, assembly, and launch preparation are discussed in 3.2.4.

3.4.2 Supply

Not applicable

3.4.3 Facilities and Facility Equipment

TBD

3.5 Personnel and Training

HAC shall provide training and information to Platform Integrator personnel for performing the following tasks:

1. Removing the HIMSS from its storage container.
2. Removing and replacing any protective coverings.
3. Conducting periodic checkout while the instrument is in storage.
4. Integrating and testing the HIMSS instrument on the Platform.
5. Replacing the squib simulators with live devices.
6. On-orbit checkout and operations.

Procedures for on-orbit checkout and operations will be documented in TBD.

3.6 Interface Requirements

3.6.1 Interprogram

Not applicable

3.6.2 Intraprogram

3.6.2.1 HIMSS-Platform Interfaces

3.6.2.1.1 Physical

The physical interfaces between the HIMSS and the Platform shall be TBD.

3.6.2.1.2 Electrical

The HIMSS sensor shall receive power from the Platform. The spacecraft bus shall be 120V +/- 4%. The ripple on this voltage shall not exceed +/- 2.5V. Bus transients shall not exceed +/- 34V from the nominal voltage and shall have a duration of not more than 10 msec.

3.6.2.1.3 Command and Control

The command and control interface, including reference clock signals, between the HIMSS and the Platform shall satisfy the NPOP-1 General Payload Interface Specification (TBR).

3.6.2.1.4 Sensor Data Interface

The interface between the HIMSS and the Platform Data Management System (DMS) shall satisfy the NPOP-1 General Payload Interface Specification (TBR).

3.6.2.1.5 Environmental

3.6.2.1.5.1 Magnetic Field Generation

The HIMSS shall be designed to minimize the use of magnetic materials. The residual dipole moment of the HIMSS shall be limited to TBD pole-cm. The field produced by the HIMSS at a distance of 1 foot from any instrument surface shall be compensated and shall not exceed 0.1 gauss. Hughes will measure the intensity and direction of the compensated magnetic field produced by the HIMSS, and shall provide this data to the Platform contractor.

3.6.2.1.5.2 Electromagnetic Interference (EMI) and Electromagnetic Compatibility (EMC)

The HIMSS shall comply with JSC 30237 (Space Station EMI/EMC Requirements), which specifies instrument conducted emission, conducted susceptibility, radiated emissions, and radiated susceptibility.

3.6.2.1.5.3 Thermal

The instrument interface on the spacecraft shall be within a temperature range of TBD to TBD degrees C. Thermal radiation from the Platform and its payloads (including reflections) in the direction of the HIMSS shall not exceed TBD watts/square meter.

3.6.3 Intraproject

Not applicable

4. VERIFICATION

A Performance Verification Program as specified in SFC-415-EOS-00004 (Earth Observing System Performance Assurance Requirements for General Instruments) shall be conducted to ensure that the HIMSS meets the specified mission requirements.

4.1 General

4.1.1 Responsibility for Verification

Hughes will be responsible for supplying the facilities, personnel, and test equipment to support the Performance Verification Program throughout the design, production, qualification, and acceptance testing of the HIMSS. Hughes personnel will conduct the tests in accordance with NASA approved procedures. During Platform integration, Hughes personnel and necessary test equipment will be available, and testing during the integration phase will take place at the facilities of the Platform Integrator or another location to be determined. Verification of performance after launch, through HIMSS deployment, and until on-orbit testing has been completed will be conducted by Hughes personnel with equipment (TBD) supplied by Hughes.

The Government reserves the right to witness, perform and verify the results of all verification accomplished.

4.1.2 Verification Method Selection

Verification methods will be chosen in accordance with GSFC-415-EOS-00004.

4.1.3 Relationships to Management Reviews

Management reviews of the HIMSS program will be held as specified in GSFC-415-EOS-00004, as follows:

- a. Conceptual Design and Cost Review (CDCR) - This review is keyed to the end of the definition study phase and will evaluate the design approaches and operational concepts.
- b. Preliminary Design Review (PDR) - This review shall occur early in the design phase prior to the manufacture of engineering hardware. Where applicable it shall include the results of test bedding and breadboard testing.
- c. Critical Design Review (CDR) - This review shall occur after the design has been frozen and prior to the start of manufacture of flight components. It will emphasize implementations of designs as well as test plans for flight systems including the results of developmental testing.

d. Mission Operations Review (MOR) - This review shall take place prior to significant integration of the flight system. The purpose is to review the status of system components, including the ground system and its operational interfaces with the flight system. Discussions will include integration and test planning. Hughes will support this review as appropriate.

e. Pre-environmental Review (PER) - This review shall occur prior to the start of environmental testing of the protoflight or flight system. The primary purposes of this review are to establish the readiness of the system for test and to evaluate the environmental test plans.

f. Pre-shipment Review (PSR) - This review shall take place prior to shipment of the HIMSS to the Platform for integration, and will concentrate on instrument performance during acceptance testing.

g. Flight Operations Review (FOR) - This review will emphasize the final orbital operations plans, as well as the compatibility of the Platform with ground support equipment and ground network, including summary results of the network compatibility tests. Hughes will support this review as appropriate.

h. Flight Readiness Review (FRR) - This review is to assess the overall readiness of the total system to support the flight objectives of the mission.

All reviews will be attended by project management, quality assurance personnel, and the appropriate engineering personnel. In addition, it is expected that the Technical Officer (TO) or the TO's designated representative will attend.

4.1.4 Test/Equipment Failures

In the event of a loss of function during qualification or acceptance testing, Hughes shall stop the test and contact the Technical Officer (TO) or the TO's designated representative before proceeding. Hughes would propose that the HIMSS program manager have the authority to authorize the continuation of the test in the event of a minor out of spec condition. The out of spec condition would be documented before restarting the test. Normally, the complete test will be rerun, starting at the beginning of the test in which the failure occurred, unless the retest is shortened upon direction of NASA. The exact nature of retest shall be determined by the TO.

4.1.5 Verification for Unplanned Equipment Uses

Limitations on unplanned emergency use of equipment to perform functions other than for which verified are to be negotiated as necessary between NASA and Hughes.

4.2 Phased Verification Requirements

4.2.1 Development

Verification of the suitability of the HIMSS design for meeting its mission requirements will be accomplished by a thorough design assurance and reliability program as specified in GSFC-415-EOS-00004. Hughes shall establish design criteria and standardize and control design practices. The HIMSS design shall be reviewed as described in paragraph 4.1.3 and be capable of:

- a. Functioning properly during the required mission lifetime,
- b. Minimizing or eliminating potential sources of human-induced failures,
- c. Permitting ease of assembly, test, fault isolation, repair, servicing, and maintenance without compromising safety, reliability, quality, and performance.

Hughes QA personnel shall specifically ensure that:

- a. Quality, reliability, safety, and maintainability considerations are factored into the HIMSS design,
- b. The HIMSS design is capable of being inspected and tested and will facilitate repair,
- c. The HIMSS design is producible and repeatable,
- d. The detailed HIMSS design is in accordance with the controlling design criteria,
- e. The performance, safety, and interface characteristics that require verification by analysis, inspection, and test are identified and reflected in appropriate lower-tier documentation,
- f. All processes in which uniform high-quality cannot be assured by inspection alone are identified and controls are established to ensure hardware integrity.

4.2.2 Qualification

Qualification testing of the HIMSS sensor will be performed on the first production unit, which will then be refurbished for flight. Table 4-1 summarizes the level to which each of the qualification

tests will be performed.

Table 4-1
Levels for Qualification Testing

Test	Component (Functional Unit) Level	Sensor (All-up) Level
Structural Loads	Y	Y
Vibroacoustics	Y (vibration only)	Y
Mechanical Shock	N	Y (squibs fired)
Mechanical Function	Y (ADM, BAPTA, MWA only)	Y
Thermal-Vacuum	Y (reflector only)	Y
Thermal-Ambient Pressure	Y	N
Thermal Balance	N	Y
EMC	N	Y
Leakage	Y (MWA only)	N

4.2.2.1 Structural Loads

Verification for the structural loads environment shall be accomplished by a combination of test and analysis. A dynamic model shall be created to evaluate the structural modes of the HIMSS instrument and its response to the expected vibroacoustic environment. A modal survey shall be conducted to verify that the analytic model adequately represents the instrument. The test verified model shall be used to predict for the instrument the maximum expected loads during liftoff.

4.2.2.2 Vibroacoustics

For the vibroacoustics environment, limit levels are equal to the maximum expected flight environment. The verification level is defined as the limit level plus 3 dB. When random vibration levels are determined, responses to the acoustic inputs plus the effects of vibration transmitted through the structure shall be considered. As a minimum, component random vibration levels shall be sufficient to demonstrate acceptable workmanship. For qualification of hardware, tests shall be conducted at verification levels.

4.2.2.3 Mechanical Shock

4.2.2.3.1 Self-induced

The only source of self-induced shocks to the HIMSS is the firing of the antenna deployment squibs and the squibs which release the BAPTA Marmon clamp. To verify that these shocks will not damage the instrument, the completed HIMSS will be tested with live pyros twice. After each test, proper HIMSS function will be confirmed.

4.2.2.3.2 Externally Induced

When the most severe shock is externally induced, a suitable simulation of that shock shall be applied at the instrument interface. When it is feasible to apply this shock with a controllable shock-generating device, the verification level shall be 1.4 times the maximum expected value at the instrument interface, and shall be applied once in each of the three axes. If it is not feasible to apply the shock with a controllable shock-generating device (e.g., the instrument is too large for the device), this test may be conducted at the instrument level by actuation of the shock-producing devices in the instrument-integrated payload which produce the shocks external to the HIMSS. The shock-producing device(s) must be actuated a minimum of two times for this test.

4.2.2.4 Mechanical Function

A kinematic analysis of all HIMSS mechanical operations is required

(a) to ensure that each mechanism can perform satisfactorily and has adequate margins under worst-case conditions, (b) to ensure that satisfactory clearances exist for both the stowed and operational configurations as well as during any mechanical operation and (c) to ensure that all mechanical elements are capable of withstanding the worst-case loads that may be encountered. In addition, instrument level verification tests shall be conducted to demonstrate that the installation of each mechanical device is correct and that no problems exist that will prevent proper operation of the mechanism during mission life.

Instrument verification tests are required for each mechanical operation at nominal, low, and high energy levels. To establish that functioning is proper for normal operations, the nominal test shall be conducted at the most probable conditions expected during normal flight. A high-energy test and a low-energy test shall also be conducted to prove positive margins of strength and function. The levels of these tests shall demonstrate margins beyond the nominal conditions by considering adverse interaction of potential extremes of parameters such as temperature, friction, spring forces, stiffness of electrical cabling or thermal insulation, and, when applicable, spin rate. Parameters to be varied during these high- and low- energy tests shall include, to the maximum extent practicable, all those that could substantively affect the operation of the mechanism, as determined by the results of analytic predictions or development tests. As a minimum, however, successful operation at the maximum and minimum allowable BAPTA temperatures shall be demonstrated.

4.2.2.5 Thermal-Vacuum

The thermal-vacuum test shall demonstrate the ability of the HIMSS to perform satisfactorily in functional modes representative of the mission in vacuum at the maximum and minimum allowable BAPTA and MWA temperatures, as well as during temperature transitions.

The HIMSS shall be subjected to a minimum of TBD thermal-vacuum temperature cycles. During any thermal-vacuum cycling, the rate of temperature change shall not exceed 20 degrees C per hour. At each temperature extreme of each cycle, the HIMSS shall be soaked for a minimum of 16 hours. (The HIMSS will be subjected to a minimum of 2 more thermal-vacuum temperature cycles in testing of the integrated observatory.) The hardware at all levels of assembly shall be operated and its performance monitored throughout the test. HIMSS turn-on capability shall be demonstrated at least twice during the low temperature extremes.

Temperature excursions during the cycling of components shall be sufficiently large to detect latent defects in workmanship. Cold turn-on capability shall be demonstrated as part of the thermal-vacuum testing at the component level, whenever appropriate. Components that are determined by analysis to be insensitive to

vacuum effects may be temperature cycled at normal room pressure in an air or gaseous nitrogen environment.

Outgassing procedures that are found necessary may be made part of the thermal-vacuum test operations if no unacceptable hazards are introduced by these procedures.

4.2.2.6 Thermal Balance

This verification shall demonstrate the validity of the thermal design and the ability of the thermal control system to maintain the HIMSS within the established thermal limits for the mission. The analytical thermal model shall be validated by tests conducted on the flight instrument. The capability of the thermal control system shall be demonstrated in the same manner.

4.2.2.7 EMC Testing (TBR)

Compliance with EMC requirements shall be demonstrated at the sensor level only. Tests listed in GSFC-415-EOS-00004, Table 3-2 shall be performed at the levels required by MIL-STD-462 and MIL-STD-463.

4.2.2.8 Leakage

This test shall demonstrate that leakage rates of sealed HIMSS hardware are within the prescribed mission limits. Leakage rates shall be checked before and after stress-inducing portions of the verification program to disclose anomalies caused by that portion. The final check may be conducted during the final thermal-vacuum test.

Checks at the instrument level need include only those items that have not demonstrated satisfactory performance at the component level or are not fully assembled until the higher levels of integration.

4.2.3 Acceptance

Table 4-2 lists the acceptance tests which shall be performed to verify the performance of each flight unit.

Table 4-2
Levels for Acceptance Testing

Test	Component (Functional Unit) Level	Sensor (All-up) Level
Vibroacoustics	Y (vibration only)	Y
Mechanical Shock	N	Y (squibs fired)
Mechanical Function	Y (ADM, BAPTA, MWA only)	Y
Thermal-Vacuum	Y (reflector only)	Y
Thermal-Ambient Pressure	Y	N

4.2.3.1 Vibroacoustics

For the acceptance testing of previously qualified hardware, testing shall be conducted at the maximum expected flight loads.

4.2.3.2 Mechanical Shock

The completed HIMSS will be tested with live pyros twice. After each test, proper HIMSS function will be confirmed.

4.2.3.3 Mechanical Function

Verification testing of instrument mechanical operation is required only at the nominal condition.

4.2.3.4 Thermal - Vacuum

Thermal/vacuum testing of the HIMSS instrument shall be conducted at the maximum and minimum allowable BAPTA and MWA temperatures.

4.2.4 Integrated Systems

4.2.4.1 Compatibility Test

System end-to-end testing at the instrument and Platform level is the responsibility of the Eos system contractor. This testing will be performed by that contractor at the Platform level of assembly. Hughes shall support this test effort as it applies to the HIMSS integrated with the Platform.

4.2.4.2 Mission Simulations

After completion of the end-to-end compatibility test, data flow tests shall be performed utilizing the total system in a realistic mission timeline, including external stimulus of the instruments and attitude control sensors, when practicable

Telemetry and command demonstrations shall be conducted, incorporating all the required equipment: appropriate Network elements, Nascom, Eos Mission Operations Center (EMOC), Instrument Control Center (ICC), and data processing facilities. Once the data flow paths have been verified, mission simulations will be held to validate nominal and contingency mission operating procedures and to provide for contractor familiarization training.

4.2.5 Prelaunch Checkout

Prelaunch checkout will be performed by Hughes personnel in association with the Platform contractor.

4.2.6 Flight/Mission Operations

TBD

4.2.7 Post Flight

Not applicable

4.3 Verification Cross Reference Index

TBD

4.4 Test Support Requirements

4.4.1 Facilities and Equipment

TBD

4.4.2 Articles

TBD

4.4.3 Software

TBD

4.4.4 Interfaces

TBD

5. PREPARATION FOR DELIVERY

TBD

6. NOTES

TBD

10. APPENDIX

**6.0 INSTRUMENT INTERFACE DESCRIPTION DOCUMENT -
PRELIMINARY**

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HIMSS INSTRUMENT INTERFACE DESCRIPTION DOCUMENT (IDD)

1.0 INTRODUCTION AND SUMMARY

1.1 Purpose

The purpose of this document is to define interfaces and handling requirements for the High Resolution Microwave Spectrometer Sounder (HIMSS).

1.2 Scope

This IDD covers only those interfaces between the HIMSS and the NASA Eos Polar Platform. All Internal HIMSS interfaces will be covered in separate documents.

1.3 Acronyms

A/D - Analog to Digital
BAPTA - Bearing and Power Transfer Assembly
BCE - BAPTA Control Electronics
BDU - Bus Data Unit
BSR - Bus Switch Relay
CCSDS - Consultative Committee for Space Data Systems
DMS - Data Management System
EMI - Electromagnetic Interference
FEM - Finite Element Model
FOV - Field Of View
GPS - Global Positioning System
HIMSS - High Resolution Microwave Spectrometer/Sounder
LO - Local Oscillator
MDM - Multiplexer/demultiplexer
MSFC - Marshall Space Flight Center
MWA - Momentum Wheel Assembly
NPOP - NASA Eos Polar Orbiting Platform
ORU - Orbital Replacement Unit
PSS - Payload Support Structure
QCM - Quartz Crystal Microbalance
RF - Radio Frequency
RFI - Radio Frequency Interference
RPC - Remote Power Controller
SCU - Speed Control Unit
SIC - Standard Interface Connector
SPU - Signal Processing Unit
TCS - Thermal Control System
TLM - Telemetry

1.4 Applicable Documents

The following documents form a part of this specification to the

extent specified herein. Specifications in this document shall supersede any disagreements found between it and any of the documents referenced below.

GE-SSP-DN-CTM-001	Space Station Polar Platform Contamination Control Plan
GIIS	General Instrument Interface Specification for the Eos Observatory
JSC 30237	Space Station EMI/EMC Requirements
JSC SP-R-0022	Vacuum Stability Requirements of Polymeric Material for Spacecraft Application
MIL-STD-1553B	Military Standard Aircraft Internal Time Division Command/Response Multiplex Data Bus

2.0 INSTRUMENT DESCRIPTION

2.1 System Overview

2.1.1 Mission

The mission of the HIMSS is to generate multispectral microwave remote sensing data with sufficient accuracy and coverage to support the scientific objectives of the Eos program.

2.1.2 System Description

The HIMSS is a conically scanning, multichannel, passive total power microwave radiometer for continuous operation on the NASA Eos Polar Orbiting Platform (NPOP-1). The HIMSS system is composed of three separate hardware units: (1) the sensor unit; (2) the Momentum Wheel Assembly (MWA), which compensates for the momentum of the spinning sensor; and (3) the Payload Support Structure (PSS) on which the sensor, MWA, and preconverter are mounted.

2.1.3 Overview Block Diagram

TBD

2.1.4 Isometric Sketch

TBD

2.1.5 Functional Description

The following subparagraphs describe each of the five major subsystems which, together, make up the HIMSS system.

2.1.5.1 Antenna Subsystem

This subsystem consists of:

1. A reflector to direct incident energy from the Earth into the feed horns.
2. A set of conical feed horns through which the reflected radiation passes.
3. A cold sky reflector (cold load) and warm blackbody reference (warm load) for calibration.

2.1.5.2 Receiver Subsystem

This subsystem consists of the waveguides, mixers, local oscillators (LO's), amplifiers, and detectors necessary to convert the energy incident on the feedhorns to a voltage for each channel.

2.1.5.3 Signal Processing Subsystem

This subsystem consists of:

1. The electronics required to process the voltage outputs from the receivers and format these data in a manner suitable for transmission to the Standard Interface Connector (SIC).
2. Circuitry to control the timing of the integration periods for each channel and ensure accurate coregistration of footprints.
3. Circuitry to acquire and multiplex all sensor telemetry and to process commands for the instrument.

2.1.5.4 Power Supply Subsystem

This subsystem consists of a preconverter and a bias power supply, which convert the 120V Eos platform supply voltage to the various voltages required by the HIMSS sensor. The power supply subsystem also contains regulators to ensure low-ripple supply voltages and components to isolate the power-consuming circuitry from the supply lines. A sequencing circuit ensures the proper application of power to the receiver components.

2.1.5.5 Structures, Mechanisms, and Control Subsystem

This subsystem consists of:

1. The physical structure of the HIMSS, including the HIMSS outer housing, internal equipment shelves, and the PSS, by which the HIMSS is mounted to the Eos platform.
2. The Bearing and Power Transfer Assembly (BAPTA), which provides the rotating mechanical and electrical interface between the spinning and despun (fixed) sections of the instrument.
3. The BAPTA motor, which supplies the torque for rotation of the spun section.
4. The BAPTA Control Electronics (BCE), which regulate the BAPTA motor spin rate.
5. The Momentum Wheel Assembly (MWA), which compensates for the effect of the momentum of the spun section on the Eos platform.
6. The Speed Control Unit (SCU), which is responsible for matching the MWA rotation rate to that of the sensor.

7. The heaters and blankets used for thermal control of the HIMSS.

2.2 Operating and Emergency Modes

2.2.1 Storage/launch Mode

During storage and launch, the HIMSS will be in the stowed configuration and no power will be consumed. While in storage, the HIMSS may be periodically removed from its storage/shipping container, powered up, and proper functioning verified.

2.2.2 On-orbit Mode (Mode 1)

After deployment, a command will be issued to the HIMSS to enable the MWA for normal sensor operation, in which the spun section of the HIMSS rotates at approximately 40 rpm. The torque for the rotation is provided by the BAPTA motor, and the angular velocity is regulated by the BCE. For 140 degrees active angle of each spin cycle, the sensor field-of-view will point towards the Earth, and microwave radiation emitted by the Earth will be reflected into the feed horns. This energy is converted into a digitized voltage, which is then sent to the SIC for transmission in the downlink data stream. Once in each spin cycle, the reflector-feed horn path will be interrupted by warm and cold load calibration reference targets, each covering about 10 degrees of the total rotation. The warm load reference, which will closely approximate a blackbody, will operate between temperatures of TBD K and TBD K. The cold load reference, which reflects deep space, will appear to the sensor to have a temperature of approximately 3 K. Approximately five temperature measurements of each reference load will be made during each spin cycle, and these will be incorporated into the data stream along with the Earth observations to be used later for determination of a calibration slope, which will in turn be used for conversion of the digitized voltages into calibrated brightness temperatures.

2.3 HIMSS Deployment

Deployment of the HIMSS takes place in several steps. First, the antenna and Marman clamp are released from their stowed positions by the firing of pyrotechnic pin-pulling squibs. A spring mechanism rotates the antenna support structure until it is locked in place. Power is then applied to the Signal Processing Unit (SPU), BCE, and MWA, followed by the MWA being turned on, as well as the warm-up and maintenance heaters. Next, the BCE motor driver is turned on, and the MWA is commanded to begin spinning. Once the MWA rotation rate exceeds a preset threshold, the sensor BAPTA motor begins to spin at the same rate. After the rotation rate of the HIMSS and MWA reach operational speed, the sensor transfers to a position loop, which maintain the HIMSS and MWA in proper synchronization. Finally, the maintenance and warm-up heaters are

turned off, the receivers are powered up, and data begins flowing to the Platform.

2.4 Data System (Management)

The HIMSS will be responsible for analog-to-digital conversion of the detector voltages and analog telemetry, conditioning, and conversion to a format suitable for the SIC (i.e., CCSDS source packets). In all cases, this will be performed by the onboard SPU (Signal Processing Unit). For the purposes of this IDD, telemetry is defined as any communication that crosses from the HIMSS to the platform and is subsequently sent to the ground. Communications that cross this boundary and are not included in the data stream are considered signals.

2.5 Commands

Commands are any communication from the Platform to the HIMSS that results in a specific action. HIMSS commands will take both discrete and serial forms, depending on their nature and timing. Specific command details can be found in 4.3.

3.0 MECHANICAL INTERFACE

3.1 Component Identification and Configuration

HIMSS components shall be marked for identification. Marking shall include, but not be limited to, the following:

1. Item Name
2. Part Number
3. Serial Number
4. Manufacturer
5. Actual Weight

3.1.1 Mechanical Interface Drawing/sketch/isometric

TBD

3.2 Mass Properties

Specific details regarding the mass properties of the HIMSS can be found in the preliminary HIMSS Contract End Item Detail Specification (paragraph 3.2.2).

3.3 Dynamic Properties

The minimum fixed base natural frequency of the HIMSS will exceed TBD Hz to minimize coupling to any platform resonant frequencies.

3.4 Moment of Inertia

TBD

3.5 Math Model

Hughes will provide a NASTRAN Finite Element Model (FEM) of the HIMSS. The sensor will be modelled in the launch configuration, with sufficient detail to characterize fundamental dynamic modes below 70 Hz. Since the HIMSS is a spinning instrument, and may affect the Platform's stability, a FEM of the on-orbit configuration will also be provided, using node and element ranges provided by the Platform Contractor.

3.6 Mechanical Placement Requirements

Because of its large field of view and conical scanning design, the HIMSS cannot be mounted directly on the top or bottom surfaces of the Platform. Instead, the PSS is attached to the forward section of the Eos Platform and forms a truss to which the HIMSS is mounted. Figures 3-1 and 3-2 illustrate the envelopes of the stowed and deployed configuration.

Figure 3-1
HIMSS Stowed Configuration

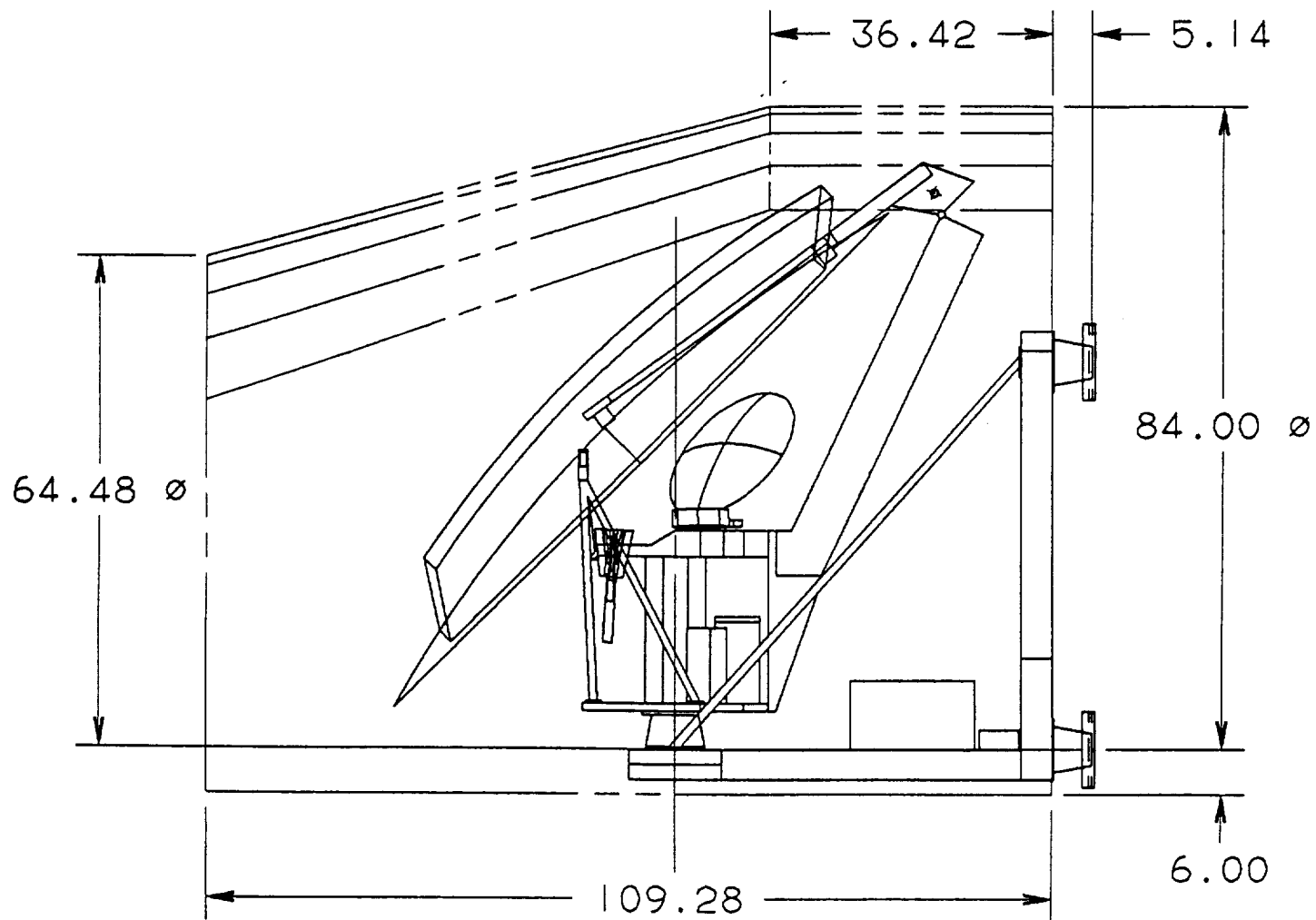
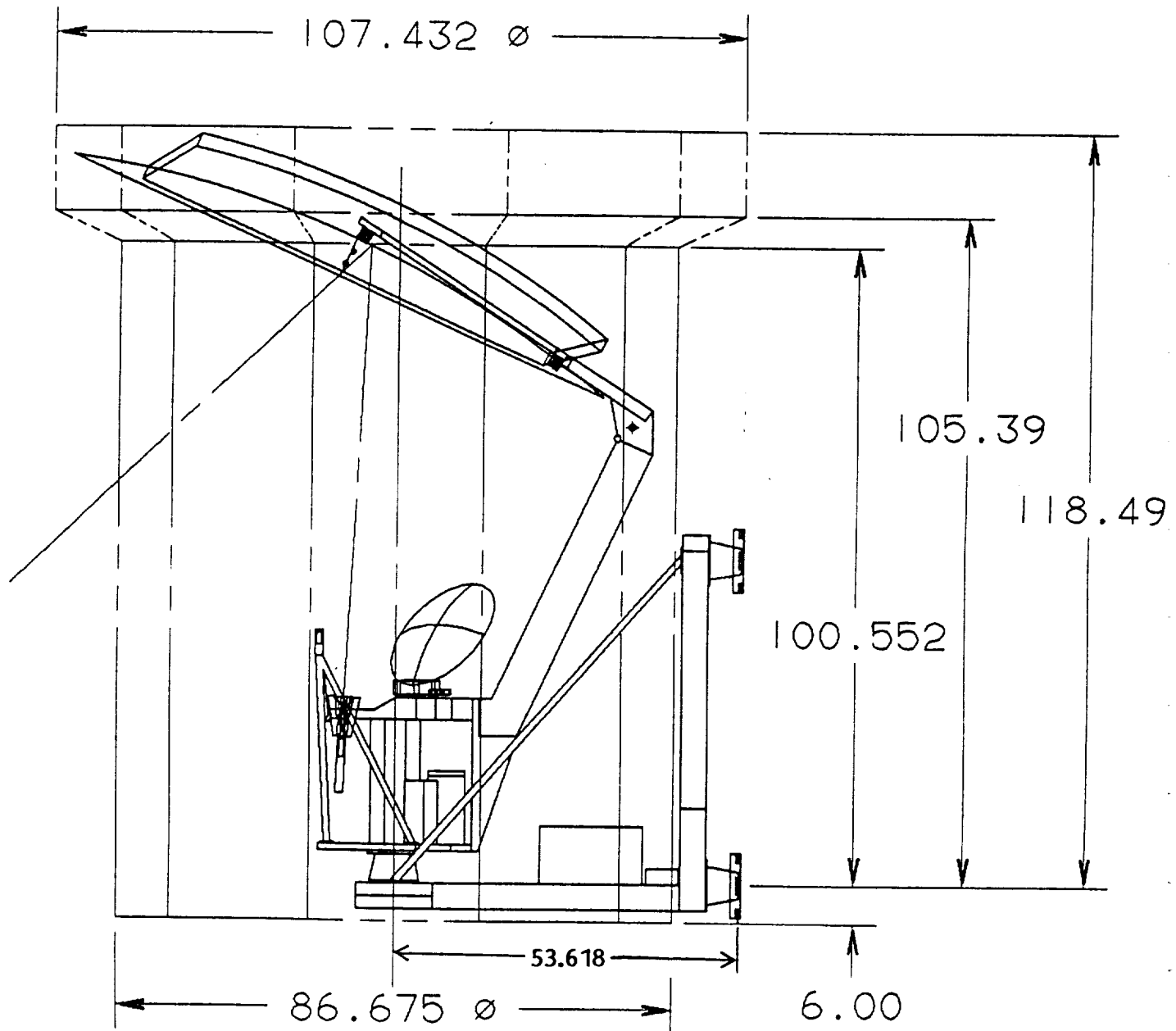


Figure 3-2
HIMSS Deployed configuration



3.6.1 Optical Fields of View

The HIMSS requires a clear field of view throughout the active portion of its scan. Furthermore, to attain the greatest degree of accuracy, the FOV of the cold sky reflector (used for instrument calibration) must also be unobstructed. Figure TBD illustrates the HIMSS FOV requirements. The HIMSS will be designed to conform to the required envelope (see 3.6) so that it does not deploy through the FOV of any other instrument.

3.6.2 Electrical Connectors

TBD

3.7 Mounting and Installation

3.7.1 Mounting Definition

The HIMSS sensor shall be mounted on a specially designed truss structure which will be bolted directly to the center and ORU longeron nodes at Bulkhead 8, at the forward (+X) face of the Platform. The MWA and preconverter shall also be mounted to the PSS. Figure TBD illustrates the manner in which the HIMSS system (sensor, MWA, preconverter, and PSS) are mounted to the Platform.

3.7.2 Handling

TBD

3.8 Alignment

Alignment of the HIMSS to the Platform will comply with the NPOP-1 Interface Specification.

3.8.1 Axes

The orbital coordinate system used in the design of the HIMSS is that used for the Platform generally, as follows: The reference geoid is an ellipsoid with center at the center of mass of the earth with a mean equatorial radius of 20,926,694 ft (6,378,145 m) and an inverse flattening of 298.25. The ZG axis is a line through the origin of the orbital coordinate reference and normal to the reference geoid on the near side. ZG is positive from the spacecraft toward the earth. The YG axis is normal to the ZG axis and to the instantaneous inertial velocity. The positive YG axis lies on the anti-sunlit side of the plane formed by the velocity vector and the ZG axis. The XG axis completes the right-handed orthogonal basis.

The sensor-relative coordinate axes for the HIMSS are parallel to the axes of the orbital coordinate system, with the Z axis being

a line passing through the center of the BAPTA. The cone angle (46 degrees) is defined relative to the positive Z axis, and the scan angle defined relative to the positive X axis with positive and negative scan angles in the +Y and -Y directions, respectively.

3.8.2 Accuracy

The maximum error of alignment is no more than TBD for each axis.

3.8.3 Alignment Reference

An optical cube is attached to the HIMSS and used to align the sensor to the alignment reference cube on the platform. The optical cube location is TBS.

3.9 Mechanical-electrical Interface

3.9.1 Connectors

To assure compatibility, all connectors directly mating with Platform hardware will be supplied to Hughes by the Platform Contractor. Hughes shall supply all other instrument connectors. All connectors shall meet the requirements of the NPOP-1 Interface Specification as follows:

- A TBD clearance will be provided between adjacent connectors. Separate and different sized connectors will be used for power, low rate data, and commands.
- All connectors will be keyed and connectors of the same type and size will have alternate keying.
- At least two pins shall be used for power, each having the capability of carrying full peak power when derated per TBD guidelines.
- Pin contacts shall be used for input signals and power. Socket contacts shall be used for output signals.
- Ten percent spare pins (minimum 2) shall be provided on each connector.
- All connectors except coaxial and pyrotechnic connectors shall have at least one pin with chassis ground and one pin with signal ground.
- Voltages higher than TBD volts shall be on dedicated connectors.
- Power and ground shall be on the same connector but physically separated to the maximum extent practical.

- Shields will not be used as return conductors, except for coaxial cables.
- Captive covers shall be provided for all connectors which will be exposed and which are not used in the normal spacecraft configuration.

3.9.1.1 Connector Pin Definitions

TBD

3.9.1.2 Harnessing

Hughes shall supply all harnessing within the HIMSS, as well as all harnessing between the HIMSS, MWA, and preconverter. No harnessing is anticipated between the HIMSS and any other Platform payload.

3.9.2 Pyrotechnics

Antenna deployment and Marman clamp release require the firing of captivated pyrotechnic pin-pullers for release from the stowed configuration. Hughes will provide estimates of the force due to the squibs firing. Premature squib activation will be prevented by requiring two separate, sequential commands for firing (i.e., "enable" and "fire").

3.10 Mass Model Definition

TBD

3.11 Access Requirements

TBD

3.12 Other Constraints

TBD

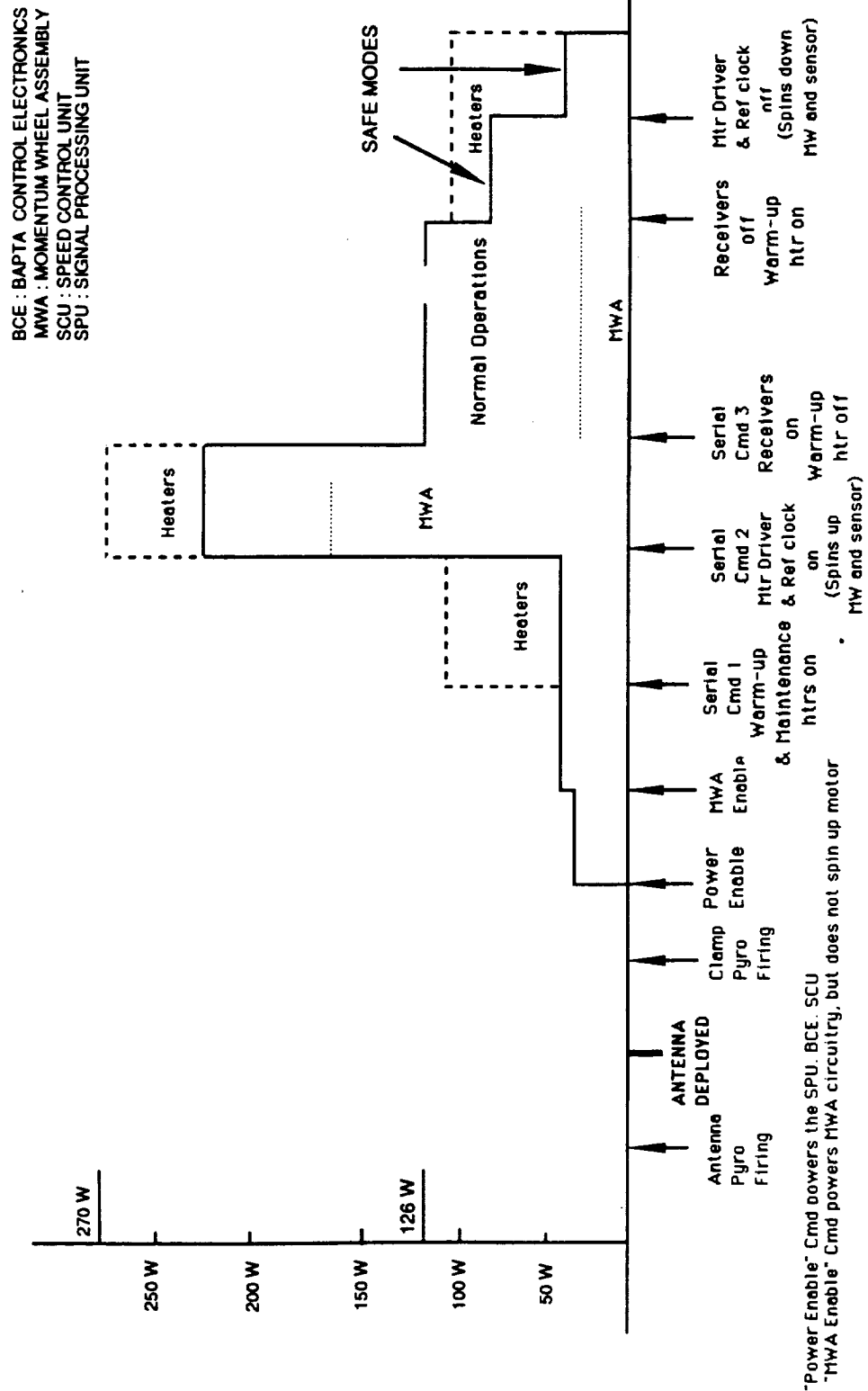
4.0 ELECTRICAL INTERFACES

4.1 Power

4.1.1 Power Profile

The HIMSS power profile is illustrated in Figure 4-1

Figure 4-1
HIMSS Power Profile



4.1.2 Power Management Requirement

The HIMSS is designed to accept power meeting the Platform specs - i.e., with a voltage of 120 +/- 4%, a ripple no greater than +/- 2.5V, and bus transients that do not exceed +/- 34V from the nominal voltage and have a duration of no more than 10 msec.

4.1.3 Power Interface (circuit)

TBD

4.2 Signals

For this IDD, signals are defined as any transmission across the HIMSS/Platform boundary that is not incorporated into the data stream to the ground. The only signals anticipated are two alarm signals to the Platform (BAPTA temperature and power consumption). Specific details regarding these signals are TBS.

4.3 Commands

4.3.1 Command Requirements/constraints

The HIMSS will accept both discrete and serial commands. Discrete commands are used to control major HIMSS functions (power enable, MWA enable, pyro enable and fire, etc.), and serial commands are used for all other functions. The subsystem control command contains bits which, when cleared or set, turn the various heaters, receiver, etc. off or on. No toggle commands (i.e., multiple functions for a single, unique, command word format) are used by the HIMSS, and no damage will result if commands are sent in an abnormal sequence.

4.3.2 Command Descriptions

TBD

4.3.3 Command List

COMMAND	TO	TYPE
Power enable	preconverter	Discrete (level)
MWA enable	MWA	Discrete (pulse)
Subsystem control	SPU	Serial
Antenna pyro enable	SPU	Discrete (level)
Antenna pyro fire	SPU	Discrete (level)
Marman clamp pyro enable	SPU	Discrete (level)
Marman clamp pyro fire	SPU	Discrete (level)

4.4 Grounding

4.4.1 Signal Ground

The signal ground is the current return path for all low voltage signals generated or used by the HIMSS. This ground shall have DC isolation of at least 10 megohms from power and chassis grounds, but may be AC coupled to those grounds by a total capacitance of up to 0.5 microfarads for RFI, EMI, and other noise suppression.

4.4.2 Shield Ground

At least one pin shall be provided for shield grounds on each connector interfacing electrically with the Platform harness, and this pin shall be connected to chassis ground within HIMSS. Shields on high-level signals (greater than TBD volts) that are internal to the HIMSS shall be grounded to chassis ground at both ends.

4.4.3 Chassis and Connector Shell Grounds

At least one pin shall be provided for ground on each connector interfacing electrically with any of the Platform harnesses. Radio frequency grounds shall be DC isolated by at least 10 megohms. The HIMSS chassis will provide a good electrical contact with the payload plate chassis ground. The measured resistance between the two shall be less than 0.0025 ohms.

4.5 Timing (clock signals)

The HIMSS will use both the coarse and precision time services provided by the Platform.

The coarse time reference will have the following characteristics:

Timecode resolution:	TBD (1 msec)
Timecode accuracy:	10 msec
Timecode format:	As defined in the GIIS

The precision time reference will consist of GPS time presented in a CCSDS Standard Calendar segmented timecode format and have the following electrical characteristics:

Interface type:	TBD
Active (high) level:	+5 VDC
Inactive (low) level:	0 VDC

Timecode update rate:	1 sec
Timecode accuracy:	TBD (+/- 10 uS relative to GPS time)
Timecode format:	As in the NPOP-1 GPIS
Reference frequency:	1.0 MHz
Reference frequency stability:	5 parts in 10E11 per day

The HIMSS will provide two independent, isolated inputs for this time interface.

4.6 Telemetry

All telemetry will comply with the bus interface requirements described in MIL-STD-1553B. Hughes will provide all of the transformers, transceivers, and protocol devices necessary to implement such an interface.

4.6.1 Science Data

The HIMSS is a low data rate instrument, so the science data will be formatted into CCSDS source packets as described in the GIIS. Specific format details for the science data are TBD.

4.6.2 Housekeeping

All HIMSS housekeeping telemetry other than on/off discrete status bits shall be digitized and formatted into CCSDS source packets for transfer to the SIC.

Table 4-1 lists the various HIMSS housekeeping telemetry items. Specific formats for serial telemetry are TBD.

Table 4-1

HIMSS Housekeeping Telemetry

Description	Type	Function
Antenna Deployment Angle	Analog	Output of Pot on the antenna
Motor ON	Digital	Verifies the "Motor ON" command
Warm-up heater ON	Digital	Verifies the "Heater ON" command
Maintenance heater ON	Digital	Verifies the "Heater ON" command
Receiver ON	Digital	Verifies the "Receiver ON" command
SPU Temperature	Analog	Unit temperature
BCE Temperature	Analog	Unit temperature
PS Temperature (2)	Analog	Unit temperature
Receiver Temp (2)	Analog	Unit temperature
BAPTA Temperature	Analog	Unit temperature
MWA Temperature (2)	Analog	Unit temperature
Sensor Current	Analog	Total sensor current
Momentum unbalance	Analog	Difference between MW rate and BAPTA motor speed
Warm Load Temp(6)	Analog	Calibration load temperature

4.6.2.1 Analog to Digital Conversion

The HIMSS shall be responsible for analog to digital (A/D) conversion of its analog telemetry. This conversion shall have the following characteristics:

Resolution:	TBD (2.5 mV)
Full Scale:	-5.12 to +5.11 VDC
Linearity:	TBD
Accuracy:	TBD
Telemetry Reference:	Signal Ground

4.6.2.2 Discrete Telemetry Interface

The HIMSS shall provide an MDM with a discrete status bit indicating its on/off status. The electrical characteristics of this interface shall be as follows:

Logic "1" level:	+5 VDC
Logic "0" level:	0 VDC
Logic "1" sink current:	TBD
Source capacitance:	TBD
Source overrange limit:	TBD
MDM input impedance:	TBD (2.8 ohms)
MDM input failure current:	TBD mA

The HIMSS shall provide two independent, isolated outputs to each redundant MDM discrete telemetry interface.

4.7 RFI/EMI Grounding and shielding provisions

TBD

4.8 Test points

The normal interface to the HIMSS during testing will be through the SIC. The Platform will provide limited access to test points on the HIMSS. In cases where access is required to a test point connector once the HIMSS has been integrated onto the Platform, this information shall be negotiated between the Platform Contractor and Hughes.

4.8.1 Test Point Signal Characteristics

Test points supplied from the HIMSS to the Platform Ground Support Equipment shall comply with the following requirements:

Signal type:	Same as a monitored signal
Signal amplitude:	Representative of monitored signal
Output configuration:	Single ended, DC coupled, referenced to signal ground
Output impedance:	2K minimum, 10K maximum
Load impedance:	2 Mohms minimum
Overvoltage due to failure mode:	TBD VDC

4.8.2 Test Point Loading

The fidelity of the test signal will be maintained with a capacitive loading of 0.002 uF due to test cable leads.

4.8.3 Test Point Short Circuit Protection

Test points shall be fail-safe such that a single point failure in the test point circuitry shall not cause the HIMSS to malfunction in any way.

4.9 Electrical Physical Interface

TBD

4.9.1 Connector Definition, Location, and Orientation

TBD

4.9.2 Pin Definition

TBD

4.9.3 Interconnect Table

TBD

4.9.4 Signal Characteristics Table

TBD

4.9.5 Signal Flow Diagram

TBD

4.10 Pyrotechnic Firing Circuits

The firing of the pyrotechnic squibs will require two separate serial commands. To eliminate the possibility of stray electrical charges from firing the squibs, the connectors carrying the squib ignition signals from the SPU are designed to provide an RF shield. In addition, a bleed resistor is placed in each firing circuit to drain off any accumulated static charges.

5.0 ENVIRONMENTAL INTERFACES

5.1 Thermal

The HIMSS will provide all necessary hardware to perform its own thermal control, and will not be connected to the Platform's Central Thermal Control System (TCS).

The HIMSS shall not conduct or radiate more than TBD +/- TBD watts to or from the Platform. Thermal radiation from the Platform and its payloads (including reflections) in the direction of the HIMSS shall not exceed TBD watts/square meter.

The Platform shall maintain the surface to which the HIMSS is mounted between 0 and 30 degrees C. The MWA shall be maintained between 0 and 30 degrees C during normal operation (MWA spinning) and between -10 and 30 degrees C when the MWA is off. When the HIMSS is in quiescent or standby mode, the Platform will maintain the temperature of the mounting plate at 20 degrees C.

5.2 EMI/RFI

The HIMSS shall comply with JSC 30237 (Space Station EMI/EMC Requirements), which specifies instrument conducted emission, conducted susceptibility, radiated emissions, and radiated susceptibility.

5.3 Magnetic

The residual dipole moment of the HIMSS shall be limited to TBD pole-cm. The field produced by the HIMSS at a distance of 1 foot from any instrument surface shall be compensated and shall not exceed 0.1 gauss. Hughes will measure the intensity and direction of the compensated magnetic field produced by the HIMSS, and shall provide this data to the Platform contractor.

5.4 Humidity

TBD

5.5 Contamination

5.5.1 Cleanliness

During integration, testing, and storage (both at Hughes and GE facilities), inspection of the HIMSS antenna and feed horns will be done using methods and at intervals TBD by Hughes. Cleaning of these surfaces is the responsibility of Hughes. The cleanliness levels of instrument external surfaces shall meet the minimum molecular and particulate cleanliness levels established for the Platform set of instruments.

5.5.2 Outgassing Material

The outgassing of HIMSS materials will be controlled by adherence to procedures specified in GE-SSP-DN-CTM-001 (Space Station Polar Platform Contamination Control Plan). Any polymeric material used in the HIMSS shall meet the requirements of NASA JSC SP-R-0022 (Vacuum Stability Requirements of Polymeric Material for Spacecraft Application) for total mass loss and collected volatile condenseable material (maximum of 1.0% and 0.1%, respectively). The HIMSS design shall not include vent paths that direct outgassing species onto sensitive optical surfaces or into the FOV of any optical instrument. Materials for which no test data exists shall be subjected to testing per the ASTM E-595 procedure and screened according to the JSC SP-R-0022 selection criteria.

Hughes will perform thermal vacuum bakeout of multilayer insulation, wire harnesses and other parts and assemblies that could generate outgassing species on orbit. This bakeout shall be performed at the maximum on-orbit temperature predicted for the parts or assemblies.

Hughes shall provide quartz crystal microbalance (QCM) data on the outgassing rate vs. time for the entire HIMSS and each subassembly, as well as mass spectrometer data for the identification of outgassing species.

5.5.3 Special Surface Precautions

TBD

5.5.4 Covers

The HIMSS will be equipped with a non-removable cover to prevent entry of any contamination or debris into the feed-horns.

5.5.5 Purging

TBD

6.0 OPERATING CONSTRAINTS

6.1 Command

6.2 Handling

6.3 Environmental

6.4 Test

6.4.1 Bench (Sensor only)

6.4.2 System (w/Platform)

7.0 SPECIAL TEST EQUIPMENT

7.1 Bench Test Equipment

7.2 Targets/Stimulators

7.3 Other

8.0 TESTING

9.0 FLIGHT ACTIVATION PLAN

10.0 SHIPPING AND HANDLING

11.0 DELIVERABLE ITEMS

11.1 Hardware

11.2 Documentation

11.3 Special Test Equipment

12.0 NOTES

